The UNESCO Courier

A window open on the world

May 1976 (29th year)
2.80 French francs

# EARTHQUAKE!

TREASURES
OF
WORLD ART

110

YUGOSLAVIA

# Neolithic eye-opener

This finely-modelled terracotta head with its prominent eyes and long nose dates back to the Neolithic era some 5,000 years ago. It was discovered in Yugoslavia near Pristina (Socialist Republic of Serbia). In recent years Yugoslav archaeologists have unearthed many human or animal pottery figurines, and realistic or stylized heads like this one, skillfully wrought by artists of the prehistoric farming communities in the Balkans. No comparable works of the same period have been found anywhere else in Europe.

Regional Museum, Pristina, Yugoslavia
Photo D. Stanimirovic © Fotogram, Paris

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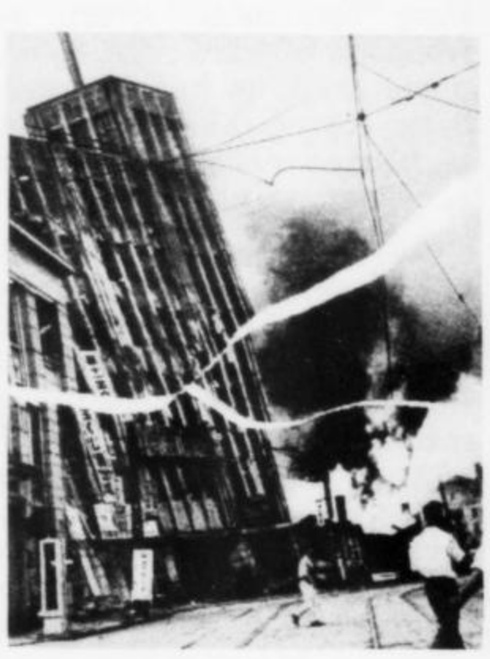

**Two billion people live in the world's seismic zones. In February of this year Guatemala was devastated by an earthquake. Where will the next one strike...? This issue discusses seismic hazards and the efforts undertaken throughout the world to improve our knowledge of earthquakes and associated phenomena, to predict them and mitigate their destructive effects. Unesco co-ordinates a wide range of activities and research in seismology and earthquake-resistant building techniques. Cover photo shows a swaying building seconds before it collapsed when an earthquake struck Fukui (Japan) in 1948. Considerable progress has been made since then in the development of quake-proof buildings.**

Design by Rolf Ibach
Photo Carl Mydans © Time Inc. 1963

# CAN WE PREVENT EARTHQUAKE DISASTERS?

## two billion people live in the world's seismic zones

***by E.M. Fournier d'Albe***

AT two minutes past three on the morning of Wednesday 4 February 1976, the stresses that had been gradually accumulating deep in the Earth's crust under the mountains of Guatemala reached the point of rupture. Within the minute that followed, 22,000 persons died, 75,000 were injured and over one million left without homes in a broad zone, 100 miles long, running south and west of Guatemala City.

Once again, an earthquake had shown its immense power of destruction, unequalled even by modern weapons of war; once again, an earthquake took its heaviest toll of human lives, among the poorer sections living in houses neither designed nor able to withstand its force.

As soon as this disaster became known, offers of help flowed into Guatemala from the four quarters of the world. The United Nations Disaster Relief Co-ordinator sent a special representative to assist the Government of Guatemala in co-ordinating this aid and in dealing with the immediate problems of rescue and relief. Unesco's help was more concerned with reconstruction after the disaster and took the form of experts in seismology, in earthquake-resistant rural housing, in school buildings and in the protection of the cultural monuments with which Guatemala is so richly endowed.

This was the immediate reaction. The basic problem remained: how to prevent such disasters from occurring again in the future. The answer is simple. The earthquake problem will have been solved when every house, every building and all the other works of man in the world's seismic zones will have been designed and built or strengthened to resist earthquakes. This will surely be done one day, but it will probably take several generations.

Why so long? The reason is, that although the general principles of earthquake-resistant design and con-

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## DEATH OF A 7-STORY BUILDING IN 15 SECONDS

**This huge mass of rubble is all that remains of a seven-story building (inset left of photo) that stood in the port area of Agadir, on Morocco's Atlantic coast. The building collapsed when a major earthquake struck Agadir shortly before midnight on 29 February 1960. In 15 destructive seconds the city almost ceased to exist: whole sections were totally destroyed, 10,000 persons were killed and 12,000 injured out of a total population of 33,000.**

Photo © Charles Vasseur, Rabat

struction are known, and the details have been worked out for modern buildings in steel and concrete and for important public works, relatively little effort has yet been put into the earthquake-resistant design of rural and low-cost housing.

In the world's seismic zones about 2,000 million people live in houses, many of which they have built themselves, not designed or engineered to resist earthquakes. It will certainly be many years before the principles and practice of earthquake-resistant building reach these grass roots. In the meantime, even in the cities, we shall have to continue for a long time yet to live and work in older buildings which are not earthquake-resistant but which, for a variety of reasons, must remain in use.

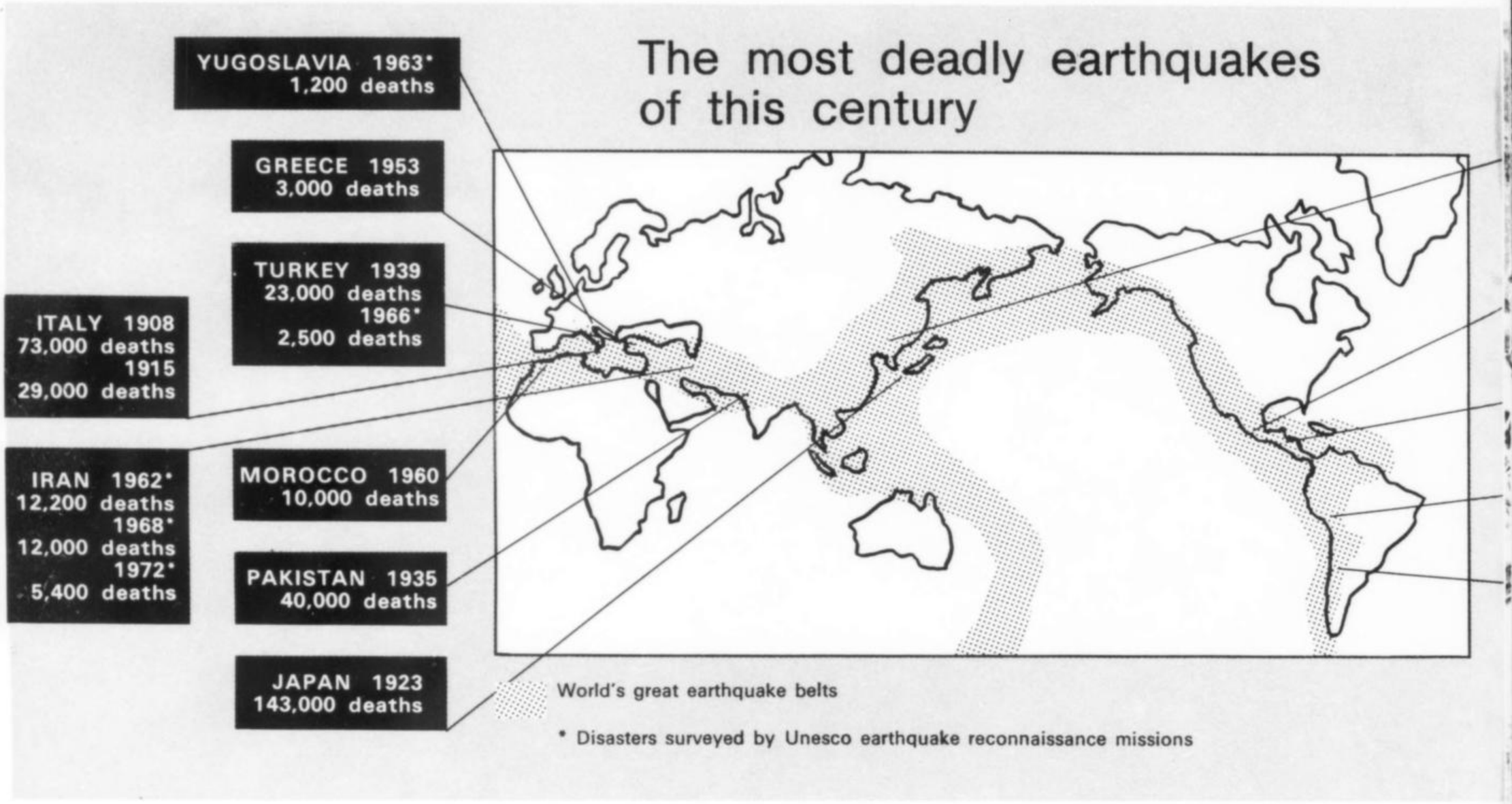
It is this that makes it so important to develop means of predicting earthquakes. This will not prevent damage but at least it will save lives if predictions can be made with the accuracy sufficient for public warning services.

The ultimate goal is to achieve immunity from earthquakes throughout the world's seismic zones. But where are these zones? It is important to know, because earthquake-resistant design and construction adds to the cost of building (between 5 and 20 per cent, according to the type of building, the materials used and the magnitude of the earthquake risk).

The main seismic zones of the world, the circum-Pacific belt, the Mediterranean - Alpine - Hindu Kush - Himalayan zone, etc., have been known for a long time, but it is only recently that the concepts of plate tectonics (continental drift) have provided a logical explanation of the large-scale pattern of seismicity.

What still remains to be done in most parts of the world is to study and define this pattern in more detail and to express our knowledge of the earthquake phenomenon in terms that are useful to the architect and the design engineer. For them, it is not sufficient simply to know that the risk of earthquake exists; this risk has to be quantified in terms of the probability of occurrence of certain accelerations or velocities of ground movement.

These and many other problems were discussed at an inter-governmental conference on the assessment and mitigation of earthquake risk that ▶




was held at Unesco headquarters in Paris on 10-19 February 1976, only a few days after the catastrophic earthquake in Guatemala. Over 180 persons attended this conference, including the delegates of 52 member states of Unesco and the representatives of 15 international organizations.

The conference had two main objectives: firstly, to examine the present state of knowledge regarding earthquakes and the means of protection against them; secondly, to identify the obstacles which prevent the fullest possible use being made of existing knowledge, and to seek ways of overcoming them. In other words, the conference looked at the earthquake problem from the governmental rather than from the purely scientific and technical point of view.

The conference thus differed from other international meetings on this subject, in that it discussed not only the nature of earthquakes and the engineering means to reduce the losses caused by them, but also their human, social and economic implications.

Some of the most interesting and fruitful discussions were those which took place between seismologists, social scientists, insurance experts and civil defence specialists. It was clear that much still remains to be done in order to provide policy makers with the data on which to base government decisions with regard to investment in earthquake research, in protective measures, or in insurance.

Another scientific subject with important human, social and economic overtones is that of earthquake prediction. The general feeling before the conference was that, although the prediction of earthquakes as a scientific exercise might well become feasible within the next few years, at least in areas subjected to intense instrumental surveillance, it would probably be a long time before the degree of accuracy required by a public warning service was achieved.

Furthermore, there was reason to believe that, in many social contexts, the announcement of an impending destructive earthquake might have consequences almost as serious as the earthquake itself, not to speak of the adverse reaction that might be expected from the public to any false alarm.

The conference therefore listened with particular interest to the report of the Chinese delegation on the methods used in that country, and

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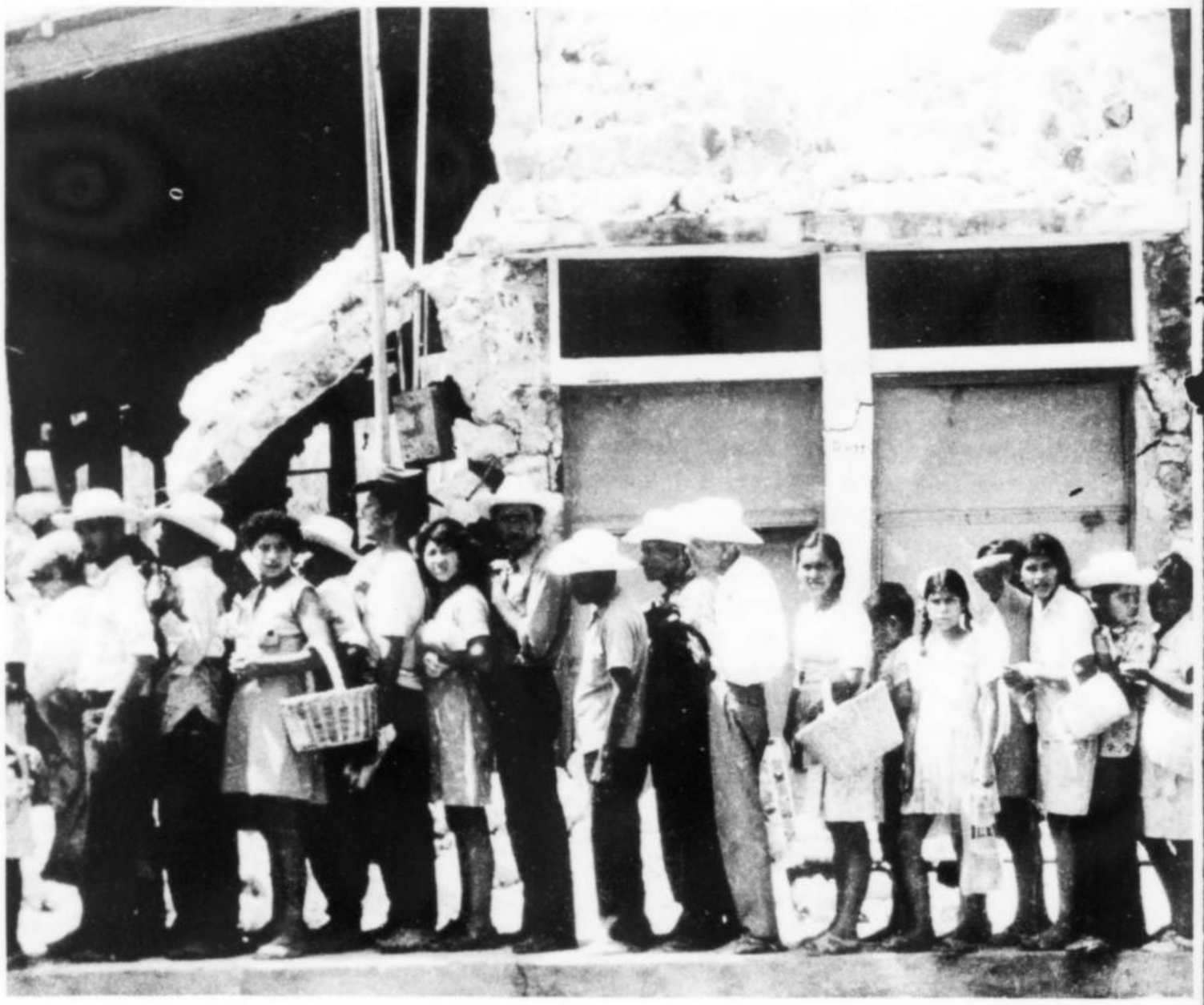

CHINA 1920
180,000 deaths
1927
200,000 deaths
1932
70,000 deaths

GUATEMALA 1976*
22,000 deaths

NICARAGUA 1972*
5,000 deaths

PERU 1970 *
52,000 deaths

CHILE 1960
5,700 deaths

# TRAGEDY IN GUATEMALA

Photos Unicef

More than 22,000 persons were killed and 75,000 injured, over 250,000 houses were destroyed and a million persons (1 person in 5 of the total population) made homeless by the earthquake that devastated Guatemala on 4 February 1976. Whole villages were demolished (above) roads were blocked, and water, electricity and communications services badly disrupted. Left, survivors line up outside a food distribution centre. The international community responded to the needs of stricken Guatemala with public and private aid. The U.N. and Unesco immediately responded ; UNICEF (the U.N. Children's Fund) made available $100,000 and began helping with relief operations within hours of the quake, providing tents and blankets for the victims as well as medical supplies and water supply equipment.

particularly on the successful prediction of the earthquake at Hai Cheng on 4 February 1975 (see article page 11).

The wide range of scientific techniques employed and, above all, the involvement of large numbers of amateur observers in efforts to detect the signs of imminent earthquake shocks, were of particular interest and demonstrated that, in the Chinese context at least, an earthquake warning system can be made to operate successfully.

The ensuing debate on this subject showed that, while the general scientific approach to the earthquake prediction problem was the same in all countries, the social problems raised by earthquake forecasting were likely to differ widely from country to country.

The conference adopted over 40 resolutions on technical matters, whose implementation will demand many years of effort on the part of Unesco and of its member states. Will this effort be made? In these days of financial stringency, this is a question that may well be asked. Although no immediate answer can be given, it is worth looking back at the years that have passed since the first intergovernmental conference on earthquakes in 1964 and noting the progress that has been made since then:

- establishment of an International Seismological Centre (in the United Kingdom) which uses one of the world's fastest computers to process the data coming into it from observatories all over the world and to produce its definitive monthly bulletin of earthquakes;
- creation of a Regional Seismological Centre for South America (Lima,

Photo © The Mainichi Graph, Japan

**WHEN THE GROUND GAPES UNDERFOOT.** Jagged crevasses in a road at Niigata (Japan) after an earthquake on 16 June 1964. The frequency of earthquakes in Japan has obliged Japanese architects and engineers to carry out considerable research into earthquake-resistant construction.

Photo © APN, Paris

**EARTHQUAKES MADE TO MEASURE.** Soviet Central Asia is a region of intense seismic activity. Violent earthquakes destroyed almost all the old buildings of Ashkhabad, capital of Turkmenistan, in 1948 and those of Tashkent, capital of Uzbekistan, in 1966. Earthquake risk was thus an important factor in plans to rebuild these two cities. Soviet specialists have developed special "vibrating machines" enabling them to subject buildings to the equivalent of seismic shocks. Left, technicians set up the vibrating machine on a rooftop in Alma Ata, capital of Kazakhstan. At the Research Institute of Geophysics and Earthquake Engineering in Leninakan, Soviet Armenia, scientists have established that there exists in certain rocks a type of magnetization, sensitive to mechanical stress, whose changes can be used to help forecast earthquakes. The Institute is therefore developing the instrumentation required for monitoring these changes.

Peru) which acts as a link between the national seismological services and co-ordinates regional studies of seismicity and earthquake risk;

● establishment of an International Institute of Seismology and Earthquake Engineering (Tokyo, Japan) which since 1964 has trained more than 200 scientists and engineers from over 40 different countries;

● planning and execution of a Survey of the Seismicity of the Balkan Region, which brought together seismologists, geologists and engineers from five countries in a pioneer effort to define seismic risk on a regional basis and in terms directly applicable to earthquake-resistant design and construction;

● installation of a uniform network of modern seismographs in four countries of South-East Asia, and the training of the scientific and technical personnel to operate this network;

● establishment at the University of Skopje (Yugoslavia) of an Institute of Earthquake Engineering and Engineering Seismology. It has become one of the leading centres of training and research in this field;

● launching of a large-scale research programme in soil dynamics at the National University of Mexico, directed particularly at the design of foundations for buildings in earthquake zones;

● the holding of two international symposia on induced seismicity, especially that resulting from the filling of large reservoirs (see page 23).

Many of these achievements depended of course upon the financial support received from the United Nations Development Programme. Others may be cited, but the point has been made that progress in this field, although slower than some might have wished, has been steady and may be expected to continue in the future, despite financial uncertainties.

This is because there is a basic economic justification for this work. A single earthquake may cost a country more than its annual national budget and may set back its economic progress by 5 or 10 years. Since 1964, more than 100,000 human lives have been claimed by earthquakes and the damage caused by them throughout the world must be reckoned in billions of dollars. The cost of seismological research, of seismic zoning, of earthquake prediction and even of earthquake-resistant building is small in comparison.

We now know enough about the cause of earthquakes, the slow but inexorable movements of the crust driven by forces deep within the earth, to be convinced that these movements have been going on since our planet was formed and will probably continue for thousands of millions of years in the future. They are part of the "life process" of the earth by which the crust is constantly renewed and which, by the way, is responsible for the formation of the minerals on which our present civilization is based.

The instantaneous destruction and loss of life inflicted by earthquakes can only be compared with that inflicted by modern weapons of war. It seems right, therefore, that Unesco, which seeks to prevent such human folly, should equally be concerned with protecting mankind from nature's violence.

We have been too long accustomed to people dying in earthquakes. We must learn to live with them.

■ ***E. M. Fournier d'Albe***

**SKOPJE RESURGENT. The city of Skopje (Yugoslavia) was rocked in 1963 by a violent earthquake. Within 17 seconds three-quarters of the city lay in ruins. The U.N. immediately organized an international relief operation, and teams, supplies and equipment were rushed to the scene. A competition was launched for the best plans for rebuilding the city centre. The winning entry came from a team led by the famous Japanese architect Kenzo Tange. Below, Kenzo Tange and colleagues with a model of their project. Since then Yugoslav town-planners and architects have rebuilt Skopje, with the collaboration of a number of international experts.**

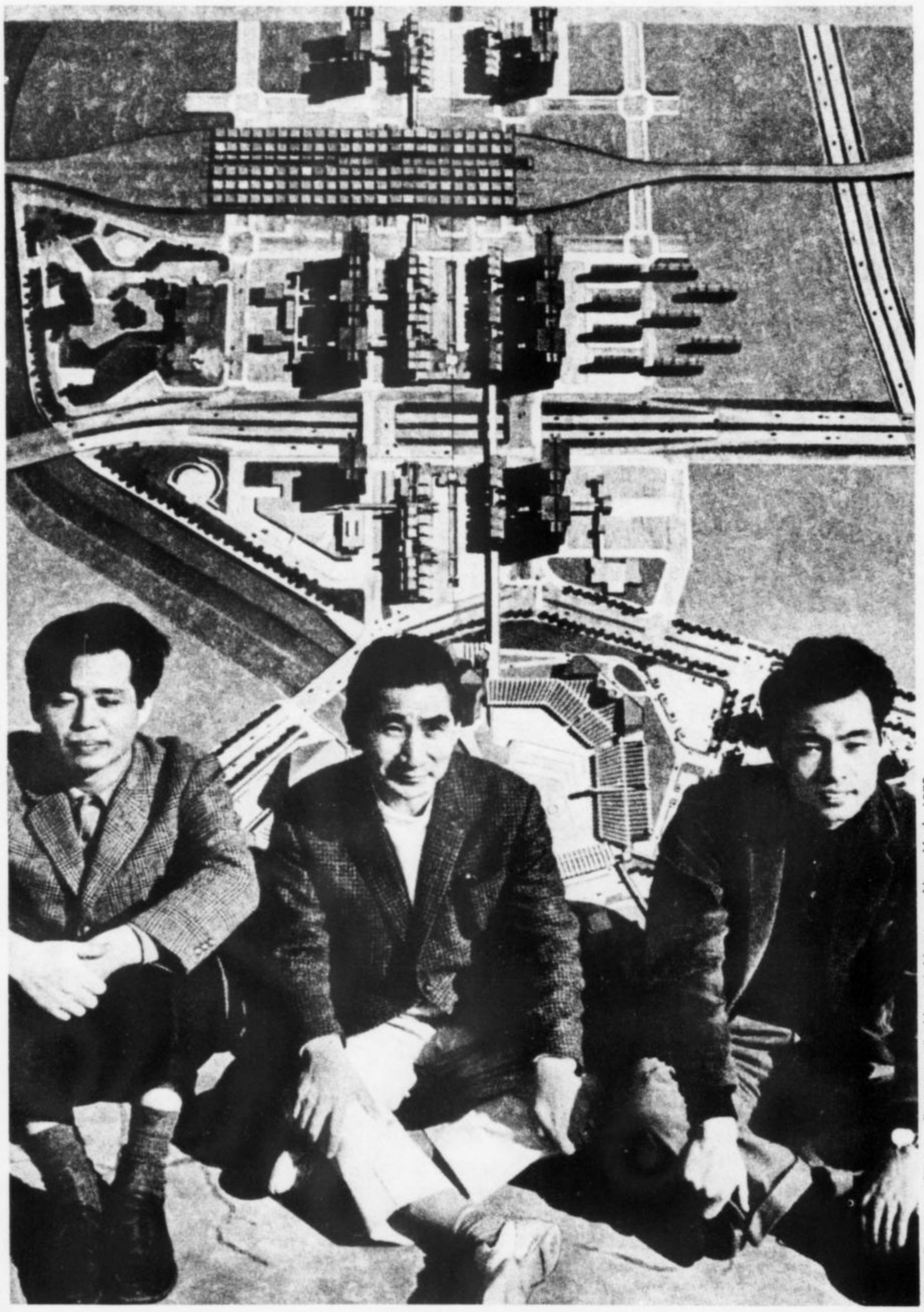

Photo © from "Skopje Resurgent". United Nations, New York 1970

# Beyond good and evil : the fabulous dragon

This composite monster with a lion's head, eagle's talons and serpent's tail is a "tatsu" or Japanese dragon which, according to Japanese legend, makes the earth "quake" when it bestirs itself. The ancestor of the tatsu was no doubt the Chinese dragon which, so tradition in China has it, hides in the caverns of inaccessible mountains or lies coiled in the ocean depths, waiting for the moment to unite earth and water, to make rain or fine weather, to herald the spring with the return of nature's energies and the explosion of new life. Unlike the malevolent dragon of the West, in East Asia the dragon is the genius of goodness and strength. It is the spirit of change, therefore of life itself. At the spring equinox it ascends to the skies, and in autumn buries itself in the watery depths. According to the Book of Divination, *Yi King*, the dragon's blood is yellow and black, corresponding to Heaven and Earth respectively. The emblem of vigilance and security, the dragon guards the treasures of the gods, carrying out their will as the spirit of order and creation in the universe. In Chinese chronology, based on a cycle of 60 years, each year is named after a symbolic animal which reappears every 12 years. This year, 1976, in China is the year of the Dragon, the fifth animal in the cycle, following the year of the Hare and preceding the year of the Snake. From the 2nd century B.C. (Han dynasty) onwards, the dragon was the emblem of imperial power and the symbol of the emperor who like the dragon was said to "hold a brilliant pearl in his mouth". Hence the "dragon pearl" came to symbolize perfection of thought and word befitting the leader, and was associated with one of the "eight treasures" of Chinese symbolism.

Photo © Giraudon, Paris

For the first time in history

# CHINA PREDICTS A MAJOR EARTHQUAKE AND SAVES AN ENTIRE POPULATION FROM DISASTER

***by Dan Behrman***

AN international scientific meeting at Unesco headquarters in Paris took a dramatic turn recently when, for the first time in such a setting, the story was told of a successful attempt to predict a major earthquake and to get an endangered population out of its way. The report was given by China to the Unesco Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk, at a special session devoted to earthquake prediction.

The Chinese delegation, headed by Liu Ying-yung, director of his country's State Seismological Bureau, told of methods used to forecast the Haicheng earthquake that occurred in Liaoning Province on 4 February 1975 with a magnitude of 7.3 on the Richter scale (1).

The delegation also described China's effort to develop a seismological network which has been termed "the equivalent of an Apollo space programme". The genesis of the effort was traced to the severe earthquake that struck Hsingtai in Hopei Province in 1966 and led the late Premier Chou En-lai to set a priority on seismology.

China now has 10,000 professional and 100,000 amateur seismologists in a network comprising seventeen standard stations and nearly 300 regional stations. By enlisting amateur observers—who include farmers, workers, teachers, telephone operators, meteorologists and radio broadcasters—the Chinese have sought to give the population at large a role and a stake, to put the citizen on the same side as the scientist.

From the very start of the programme, Liaoning Province looked suspicious. Following the earthquake at Hsingtai, seismologists noted that the epicentre of subsequent smaller shocks seemed to be migrating northeast towards Liaoning, heavily populated and industrialized. In 1970, a decision was taken to keep a close watch on the province. This involved all the techniques in the seismologist's panoply, starting with the study of past earthquakes and local geology.

Geodetic surveying across a major fault between September 1973 and June 1974 showed that the earth's surface there was rising twenty times faster than in a normal year and tilting towards the northwest. During the same period, a change was recorded in the earth's magnetic field and tidal stations over on the shore of Liaotung Bay showed a rise in sea level. Finally, the number of small earthquakes in 1974 was five times higher than normal.

These findings led the government to warn the population that a bad earthquake was in the offing. However, no one could yet say exactly when it would occur and other signs were sought. Among these were changes in the behaviour of animals.

The Chinese, in their report to the Unesco conference, told of such instances in the past. Two hours before the Pohai earthquake of 7.4 magnitude on 18 July 1969, a keeper at the Tientsin zoo noticed that his tigers were acting strangely and told local seismologists that "a big earthquake may be approaching". And in Szechuen Province in September 1972, a prediction team announced the onset of another earthquake after observing "the panic of chickens, pigs refusing to enter pigsties, horses and sheep running about frenziedly..."

The man in the street or on the farm is considered by the Chinese to be a valuable source of observations of changes in animal behaviour or in the level of ground water.

In December 1974, such changes were seen and reported in Liaoning. Wells in four communes suddenly turned muddy and started to bubble; rats and mice left their holes; hibernating snakes slithered out onto the ice. Then a magnitude 4.8 earthquake occurred seventy kilometres from Haicheng, leading authorities to conclude that something more serious was on the way. The local population had already been involved in "earthquake manœuvres"; now, a campaign began to teach every household what to do if an earthquake came.

Though a scientific paper, the Chinese report is almost a cliff-hanger, leaving the reader to wonder what will happen next. Early in February, animals were still acting abnormally and ▶

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(1) A scale used to measure the strength of earthquakes on which each higher number represents a tenfold increase in the magnitude of the tremors and a 30-fold increase in the energy released. A 2-point quake is barely perceptible, a 5 may cause minor damage, a 7 is severe, an 8 is a violent quake.

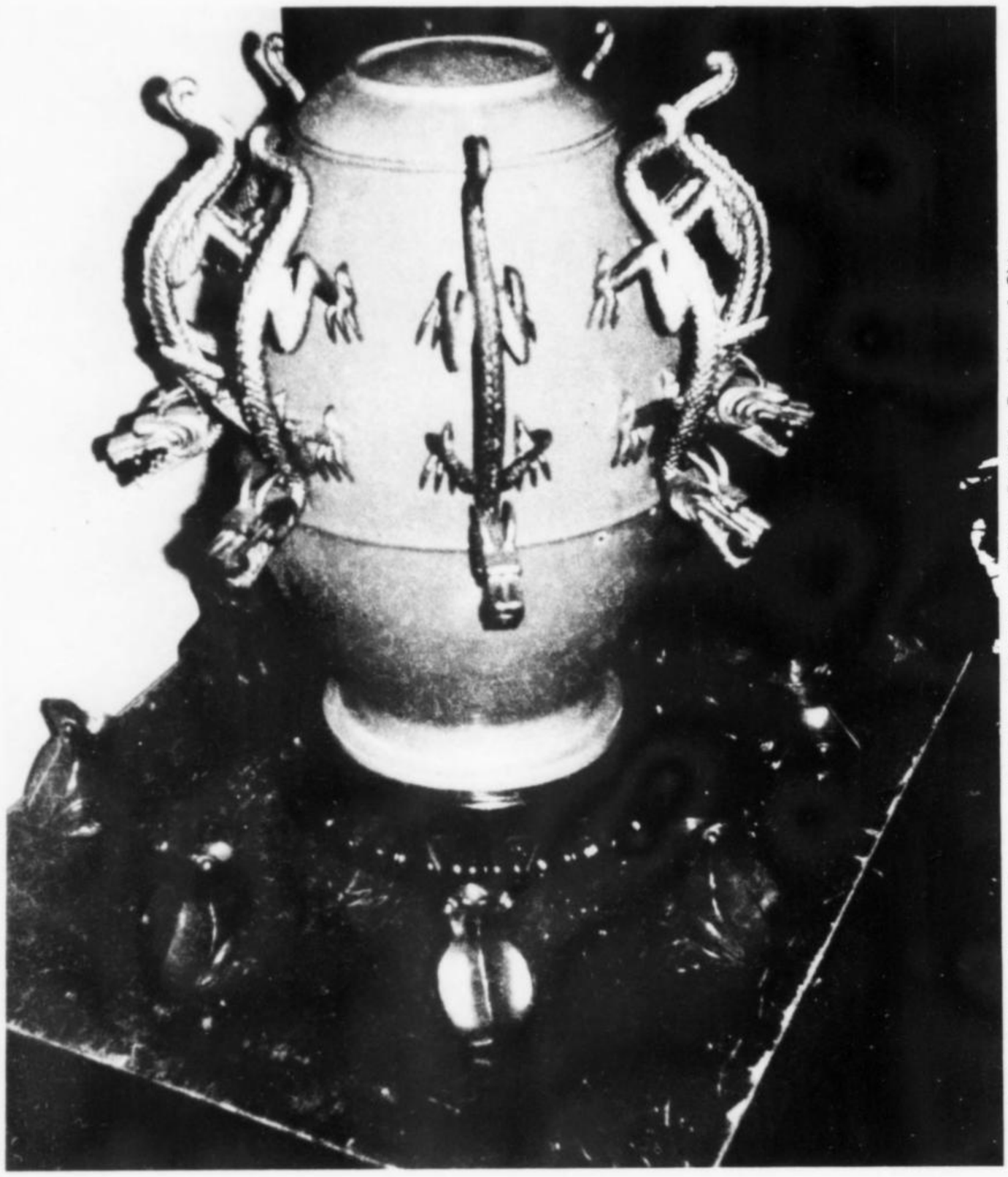
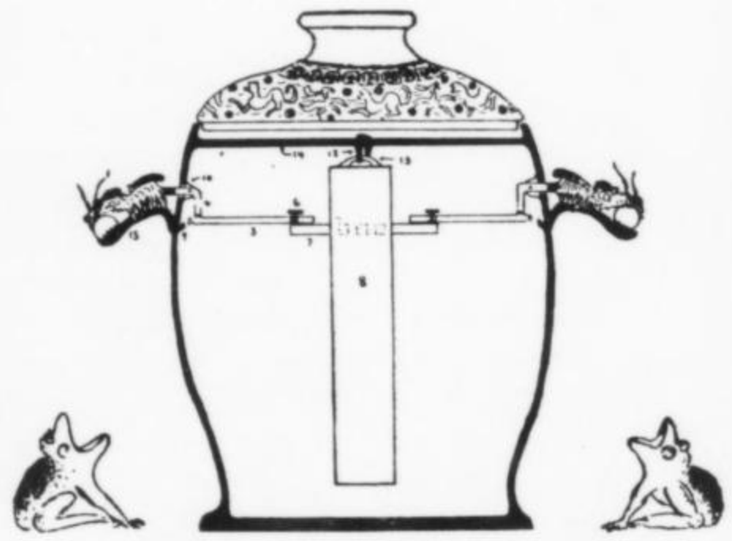


Photo © C. Weber, Orleans, France — Museum of Geology, Peking, People's Republic of China

# ANCESTOR OF ALL SEISMOGRAPHS

**The Chinese have the double distinction of having kept faithful records of earthquakes from very early times—since 780 B.C.—and of inventing the first instrument capable of detecting them at a distance. The Chinese ancestor of all seismographs was produced in 132 A.D. by a famous mathematician, astronomer and geographer named Chang Heng (78-139 A.D.). His instrument was fitted into a large ornamented bronze vessel (as shown in drawing on right and in facsimile, at left, in the Museum of Geology at Peking).**



From Volume III "Science and Civilization in China" by

wells showed disquieting signs. Twenty-two became artesian; in a hot-spring resort, the opposite happened when the flow of water was cut off three times. The report stated: "The most peculiar case took place at the Shaozihe Commune in Youyan Country where gas-bearing water spouted forth from ice like geysers."

The pace of events quickened. On 2 February, an abrupt fall in terrestrial electricity was recorded at one seismological station; at another, the tilt of the earth's surface was seen to move towards the southwest.

One wonders just what made the Chinese decide when the earthquake would strike. Apparently, the last straw was a series of small earthquakes that began on 1 February in a region that had been almost non-seismic previously.

Seismologists studied the location of these shocks and the direction taken by their so-called P-waves [seismic waves that cause rocks in their path to compress and then expand in the same direction as the waves are travelling]. The scientists concluded that these were the forerunners of a much larger earthquake likely to hit the Haicheng-Yingkou region.

The scientists passed their findings to the local government. An hour and a half later, a meeting at Haicheng decided that it was time to move from earthquake manœuvres to reality. "Without delay, people were notified to build temporary huts, to move patients from hospitals, to concentrate transportation facilities and important objects, to organize medical teams, to persuade people to move out of their houses, to move the old and weak to safe places. . ."

At 7:36 p.m. on 4 February 1975, the Haicheng earthquake came at last. But, reported the Chinese, loss of life was greatly reduced because most people had left their homes. Vehicles had been moved from garages and farm animals from barns. "Within the most destructive area, more than 90 per cent of the houses collapsed to some extent, but many agricultural production brigades did not suffer even a single casualty. In the Dingjiagou brigade of Haicheng, consisting of more than 3,000 persons, only one child was injured."

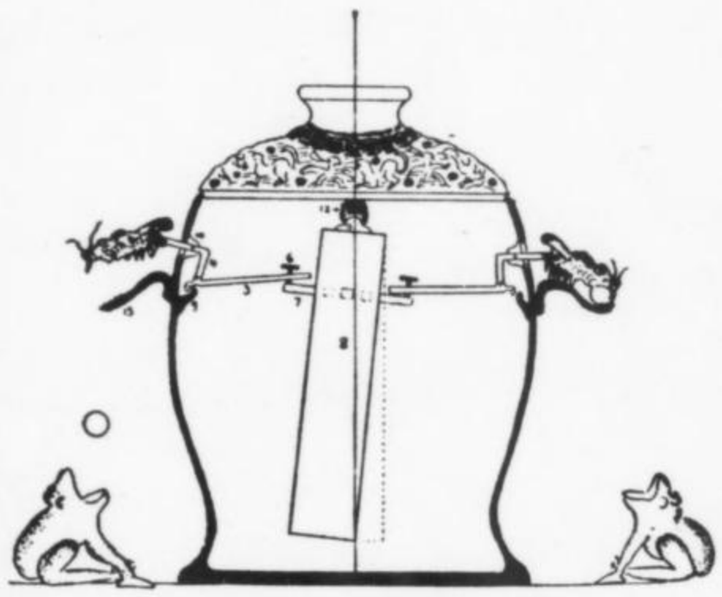
On one street in Yingkou, 3,470 persons came through with no casualties, although 82 of their 801 homes collapsed completely. "However," said the report, "in certain communes and brigades, such as the Shinpengyou brigade, two commune members, influenced by old ideas, did not believe the prediction of a strong earthquake. They brought their children back to sleep in the evening of 4 February. As a consequence, among more than 3,400 people in this brigade, three died in the earthquake".

This led the Chinese to conclude that if earthquake losses are to be reduced, one must not only estimate the danger accurately but, at the same time, educate those who are at risk, making certain that the seismologists' findings do not remain arcane secrets. There is a human side as well: "Let seismological work be really considered as the task of the masses of the people as well as of the governmental seismological brigades."

A similar attitude was expressed at the Unesco conference by Rasnar Stefansson of the Icelandic Meteorological Office who told how an earth-

Photo © N.N. Ambraseys, U.K.

**Drawings below explain how it functioned. Inside the vessel was a heavy pendulum connected to eight mobile arms. At the end of each arm a crank operated the jaws of a dragon head (eight heads in all). Earthquake shocks vibrated the mechanism causing the dragon's jaws facing the direction of the shock to open, dropping a ball into the mouth of one of the eight toads placed around the instrument. The position of the ball thus indicated the direction from which the seismic shocks had originated.**



Prof. Joseph Needham © Cambridge Univ. Press, U.K.

quake swarm had struck the north of his country near the end of last year. Within a month, it generated no fewer than 10,000 earthquakes that could be felt without instruments, 100 of them greater than magnitude 4.

On 25 December 1975, he was able to tell local sheep-raisers that there was no need to fear any more severe shocks. He emphasized that the population must be involved: "If you explain what you know and what is happening, people won't hold it against you if you make mistakes."

This is all the more important in China with a great density of population living in seismic zones. It was in China that the most disastrous earthquake of all time occurred at Huahsien in Shensi Province in 1556, leaving 820,000 dead.

Traditional Chinese houses are built with heavy roofs that protect them from the climate but can prove lethal in an earthquake. Replacing them with earthquake-resistant housing is a long job. Until it can be done, prediction is the best safeguard.

The Chinese delegation stated that more than ten earthquakes with a magnitude greater than five have been forecast. However, this is only a "small percentage" of all that occur because few observations are available from remote areas in western China.

Other countries, notably Japan, U.S.A. and U.S.S.R., have been conducting research in earthquake prediction and reported some of their findings at the conference. Dr Robert Hamilton of the U.S. Geological Survey told how the San Andreas Fault in California has been instrumented with fifty tiltmeters in deep and shallow holes while laser-ranging instruments sensitive enough to detect one centimetre of crustal deformation over ten kilometres have been set up.

The tiltmeters have shown the most promise. Since November 1974, three earthquakes of magnitude 4 or greater on the San Andreas Fault were all preceded by a tilt anomaly. About a month before the earthquake, the instruments start to deflect and keep on deflecting until it occurs.

"Precursors do exist and prediction is feasible," Dr Hamilton said, "but a prediction sufficiently reliable to be useful to us does not exist." Nevertheless, it was the policy of the U.S. Geological Survey to inform the public of what it observes, rather than withhold information for fear of raising an alarm. "We see no alternative," said Dr Hamilton.

One should note that stakes are not the same everywhere. In the United States, only 1,600 lives have been lost to earthquakes during the entire history of the country and the typical American wooden dwelling can be expected to ride out most shocks. Even so, earthquake prediction in the United States is a delicate matter and is likely to be so in any developed industrial country.

An American study has shown that property values can be expected to drop by as much as 60 per cent in the event of the prediction of a 7.3 magnitude earthquake while construction comes to a halt and overall business activity declines by a quarter. Such are the problems that are likely to appear in the not-so-remote future as the prediction of earthquakes is fined down to an exact science.

■ ***Dan Behrman***

On 8 July 1975 the ancient city of Pagan in Burma was rocked by an earthquake. Of all the great centres of Buddhism in Asia few boast such a concentration of religious edifices as Pagan with its forest of pagodas and stupas. All told some 5,000 monuments extend across a site covering over 70 sq. km. In Pagan's fantastic landscape some stand out glistening white against their red-brown weatherbeaten neighbours. A Unesco mission was sent to Pagan in November 1975 to assess the damage to the temples and advise on urgent restoration work.

# PAGAN

## BURMA'S ANCIENT CITY OF 2,000 PAGODAS DAMAGED BY A VIOLENT EARTHQUAKE

Photo © J.A. Lavaud, Paris

***by Pierre Pichard***

IMAGINE one of the great religious capitals of the world—Rome, Cairo or Kyoto, for example—deserted by its inhabitants. Imagine that all its dwellings—the palaces of the mighty, the villas of the rich and the homes of the poorer neighbourhoods—had today completely disappeared, but that its countless religious edifices were still standing, with churches, mosques or temples set in open country, monasteries encircled by ploughed fields, and minarets or bell-towers looking down on farming villages.

This astonishing spectacle you have conjured up is exactly what we find today at the site of Pagan, capital of the first Burmese royal dynasty, a city which stood on a vast cultivated plain of the Irrawaddy river, surrounded with fields of sesame, peanuts and corn, and villages set among clusters of trees.

Dwellings, markets and palaces, built of wood and bamboo, have been effaced by the centuries. The only remaining trace of secular architecture is the wall around the ancient city, said to have been erected by King Pyinbya in the ninth century A.D.

Here are more than 2,500 religious edifices of all shapes and sizes, some assembled in great constellations, others in small groups and others again standing in isolation. All these monuments within an area just under 80 square km are cared for by Burma's Department of Archaeology which has carried out an inventory of all the remains. Monuments at Pagan total some 5,000 if all the archaeological vestiges are included.

Pagan has two main types of monument:

■ **Stupas** or pagodas, masonry constructions enclosing some venerated relic. They frequently stand upon several terraces arranged in tiers, and are reached by flights of steps on each facade. The main structure, generally circular in plan, suggests an enormous bell surmounted by a delicately wrought flower-shaped metal ornament.

The Shwezigon pagoda is the most famous and attracts numerous pilgrims, especially during festivals, occasions when traditional theatrical perform-

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**PIERRE PICHARD,** *French architect, was sent to Burma by Unesco in 1975 to assess the damage caused by the earthquake in the ancient city of Pagan and to report on the restoration needs of its monuments. Between 1969 and 1971 he taught at the School of Architecture at Nantes (France). He has also carried out restoration missions for Unesco at Panom Rung (Thailand) and Paharpur (Bangladesh).*

ances, music and dancing take place, and great markets are held. The offerings of the pilgrims help to maintain the gold-leaf coating, periodically renewed over the entire surface of the edifice.

■ **Temples,** known in Burmese as *gu* or "grottoes" are the second type of monument. The name is clearly an allusion to the ancient temple-caves of Buddhist India, but also indicates how they differ from the stupas, for what counts here is the space left inside for people to walk around the statues of Buddha.

The main structure is usually shaped like a cube surmounted by tiered terraces, crowned either with a tower known as a "sikhara" or with a masonry bell resembling a stupa. Rising overhead is the summit ornament with its slender spire. At the terrace corners, where the steps lead off, there are turrets, urns or small stupas.

The tallest temple in Pagan, the Thatbyinnyu, is 64 metres high, the height of a 20-storey building, and comprises corridors on four levels, a wide vestibule, a vast sanctuary, and terraces.

In addition to the temples and stupas, there exist numerous monasteries, other partly underground edifices (temples or monasteries), vaulted rectangular rooms known as "ordination halls", subsidiary structures such as walled enclosures and gate-lodges, and some ornamental pools, reservoirs and canals.

The decoration inside the temples is mostly the work of painters. The paintings, in vivid colours (often dulled by time but which careful cleaning restores) cover the walls and the vaults, either as great panels in broad compositions featuring numbers of human figures, or as small groups of individual scenes, frequently accompanied by inscriptions not unlike modern comic strips.

These scenes illustrate the *jatakas*, tales of the former lives of Buddha. Colour is enhanced by outline drawing felicitously emphasizing expressions on faces, details of clothing or objects, attitudes of animals, as well as depicting decorative plant motifs.

Sculptors have also left their mark: imposing statues of Buddha, smaller statues placed in the many niches, or, at the Nanpaya temple, four stone pillars decorated with extremely beautiful sculpture carved in low relief.

Although numerous legends attribute very great antiquity to the city of Pagan and suggest that the royal dynasty was founded about 108 A.D., inscriptions and other historical evi- ▶

dence provide a more scientific basis for a history of Pagan beginning with the reign of Anawrahta (1044-1077 A.D.). And although several archaeological finds have revealed that the site has been occupied since neolithic times, the oldest monuments of Pagan would appear to date from no earlier than the eleventh century A.D.

Anawrahta is said to have conquered the Mon kingdom of Thaton (in the south-central part of present-day Burma) in 1057, and to have brought to Pagan Thaton's captive king, artisans, workmen, architects and scholars, as well as the sacred texts of Theravada Buddhism, the religion of Burma down to the present day.

The kingdom of Pagan extended almost to the frontiers of modern Burma, and was to last for two hundred and fifty years: it collapsed before the Mongol armies of Kublai Khan, then master of China, which took Pagan in 1287 A.D. The Peking court thereupon broke up the kingdom into small rival principalities, and the last kings of Pagan were rulers in name only. It was from other capitals such as Toungoo, Ava, Pegu and Mandalay, that later Burmese dynasties succeeded in restoring the unity of the kingdom.

However, the city was never completely abandoned. Paintings in the underground temple of Kyanzittha Umin feature Mongol soldiers, showing that work continued under their occupation. Even later, a few monuments were constructed, and others decorated, right down to the eighteenth century. The most celebrated sanctuaries have been cared for by monks from neighbouring monasteries until our own times.

ON 8 July 1975, this unique site was rocked by an earthquake. An initial series of vertical tremors at 6:35 in the evening was followed by a few seconds of calm, and then horizontal movements in a northeast-southwest direction. Amid the din of collapsing masonry, monuments disappeared in enormous red clouds which slowly deposited the dust of crushed mortar and bricks.

Staff from the Department of Archaeology set out as night was falling to assess the damage and for several days despatched to the capital a growing list of damaged monuments. Fortunately, however, the earthquake had claimed no victims.

The tremor reached an intensity of 8 on the international scale (graduated from 1 to 12), and its magnitude on the Richter scale was estimated at 5.6. The epicentre seems to have been quite close. The tremor was more intense around the modern village of Pagan and along the river, where numerous monuments were heavily damaged, and less so towards the southeast.

The extent of the damage thus varies widely from one monument to another. Several factors may have either produced a combined effect or cancelled one another out. These include the site of the building, its mass, its architecture, the details of its construction and its state of preservation.

Although several monuments collapsed entirely, it was generally only the upper parts which suffered, in varying degrees. The vaults of the temples of Manuha and Mimalaung Kyaung, the upper storey of Guni North and of several other temples, collapsed into the halls or corridors. Elsewhere, damage was limited to the superstructures: steeples of stupas and sikharas, turrets, terrace walls, etc.

In general, and though spectacular, this damage has not jeopardized the stability of these monuments, and except in rare cases the work of restoration can be progressively undertaken without any difficult problems.

More serious is the structural damage affecting the upper part of the walls and the vaults which they support. Deep crevices reveal movements of inclination and subsidence which may be intensified by the thrust of the vaults.

These shaken monuments have been more or less stabilized for the time being, but are still in a dangerous condition, and major work will be required to ensure their survival: insertion of reinforced-concrete ties and countervaults, interior lining of terrace walls, etc.

The only irreparable damage was to the decorations: sculptured plaster that fell from outside surfaces and painted plaster fallen from the inside. In most cases, the fragments shattered upon striking the ground and cannot be pieced together. A few monuments lost half of their paintings in this way, but more frequently the loss amounts to 10 to 20 per cent of what existed before the earthquake. Parts still in place, but in some cases loosened, could fall at any moment.

Pagan had already experienced several earthquakes: Burma is situated in the so-called "trans-Asiatic" seismic zone extending from the Mediterranean to Indonesia. More than 400 earthquakes were recorded in Burma between 1904 and 1975, including 32 of a magnitude greater than 6. Though Pagan is located west of the most exposed region (the north-south Pegu-Mandalay fault) it suffered shocks and damage in 1948, 1965 and 1967, and five slight tremors were reported between 1968 and 1975.

Several ancient inscriptions found on monuments refer to restorations following a seismic disturbance, and a history of Burma, written by a minister, Twin Thin, relates that under the reign of Narapatisithu (1174-1211), an earthquake "ravaged the temples, monasteries and pagodas, from the southwest corner of the royal palace to the jetty of Let-Pan, and covered the ground with a network of crevices."

Hence the earthquake occurred during construction of the monuments, and was doubtless not the only one. This explains the great care taken with the foundations (which have never budged down to present times) and with the construction in general: well-baked bricks scrupulously assembled (at least on the facings), thick walls reinforced at critical points with cross-pieces or foundations of stone, vaults of carefully bonded brick, all of which prevented much more serious damage and make it possible to undertake the work of restoration under the most favourable conditions.

However, the job is sure to be long, tricky and costly. In particular, earthquakes must be regarded as a permanent threat, and the work must be capable of safeguarding structures from at least force-8 tremors on the international scale.

The great number of badly shaken monuments will require several worksites to be operating at the same time and an order of priority to be established for restoration work. The Burmese authorities and people realize the size of the job and are resolved to devote a major effort to it.

IMMEDIATELY after the catastrophe, effective temporary measures were taken: tarpaulins were installed on frames and terraces repaired to protect the monuments during the rainy season, and in numerous cases this preserved interior paintings and prevented further collapsing: scaffoldings have been erected and damage surveys prepared. Removal of debris and cleaning up were quickly done, with the aid of numerous youth movement volunteers from all over Burma.

Collections among the Burmese people have raised three million kyatts (approximately U.S. $480,000), and this sum is still intact, since the initial work was financed out of government emergency funds. An Advisory Board was set up to co-ordinate the action of several government departments and of engineers from the Rangoon Institute of Technology.

However, a job of such magnitude and urgency is an enormous one for a country to undertake alone, and it is to be hoped that international aid will be organized. The qualified workforce already available at Pagan and Rangoon will have to be increased and trained in new techniques of restoration and consolidation.

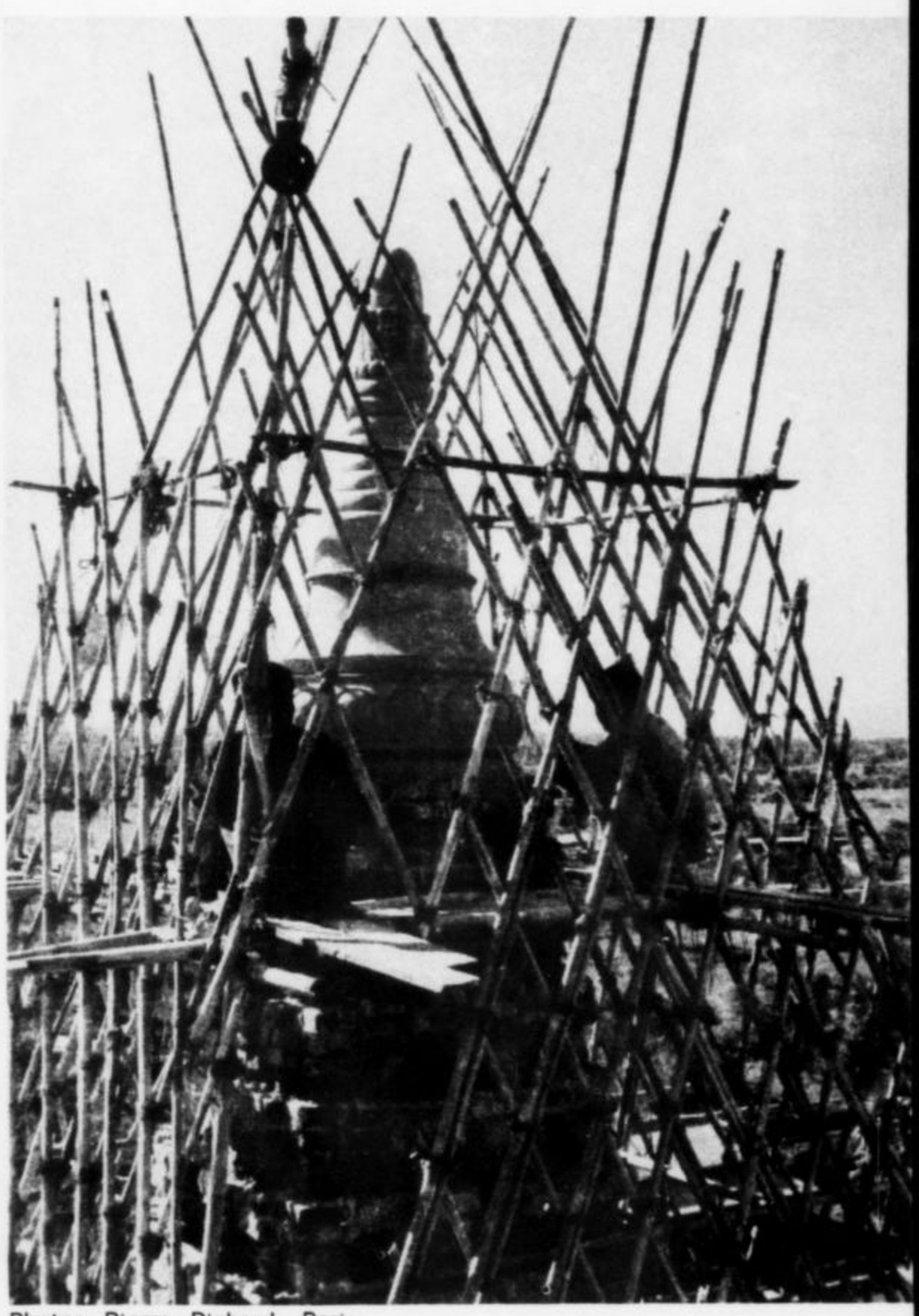
But the lack of foreign currency makes it very difficult for Burma to purchase the minimum equipment required to cope with this urgent task. An initial calculation has estimated the cost of needed equipment (cranes, trucks, concrete-mixers, drawing, surveying and worksite equipment, etc.) at around U.S. $900,000. Numerous countries and cultural institutions should be ready to share in such a worthwhile enterprise.

■ ***Pierre Pichard***

Photo Unesco - J.A. Lavaud

# ANANDA garbed in white and capped with gold

**Glittering against the skyline, Ananda pagoda is one of the most famous and best-preserved of the temples of Pagan (above). Completed in the 11th century, its plan may have been inspired by the great cave-temples of India. Damaged in the earthquake of July 1975, Ananda figured on the list of monuments for priority restoration drawn up by the Burmese authorities. Photos below show aspects of restoration work being carried out on Pagan's major edifices. Note the dense framework of bamboo scaffolding. It provides a solid structure which enables craftsmen to reach the highest and least accessible parts of damaged temples.**



Photos Pierre Pichard, Paris

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# FRAGILE TREASURES
# THE TEMPLES OF PA

**Photos on this double page show wall paintings and carvings
temples that were hit by a violent earthquake last year.**

1—Carved in the 11th century on a wall of Nanpaya temple at
this low-relief sculpture shows Brahma holding lotus flowers.
here has three faces. Only one of them can be seen on photo,
disproportion between Brahma's arm and face.

2—Many of the inner walls of Pagan's temples are decorated v
executed on dry chalk plaster. Paintings such as this one, dep
lotus flowers, were gracefully executed in bright colours thou
faded with age. The lotus is often associated with the Buddha
which germinates under the water and rises to the surface to
is born in this world and rises above it.

3—Animated scene thronged with figures is part of a large 18t
painting in the little monastery of Ananda-Okkyaung, near the
Ananda. Detail shows everyday scenes from the lives of Burm
including their construction of a temple as a votive offering.

4—Sikharas, graceful brick towers covered with carved plaste
the temples of Pagan. Fragile and delicate, they suffered seve
earthquake of 8 July 1975. Photo shows remarkable example
on the tip of a sikhara.

Photos © J.-A. Lavaud, Paris

# S FROM AGAN

vings from Pagan

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Burmese princes,
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# THE COMING EARTHQUAKE IN SAN FRANCISCO

## Scientists are certain that a major earthquake will occur in the San Francisco Bay area The only question is when will it happen

***by Karl V. Steinbrugge***

A major earthquake will strike the San Francisco Bay Area. The only question is *when* will it strike. But if disaster is thereby implied, then why is the San Francisco area allowed to grow? The answer lies in the plans and actions which have and are being taken to reduce the seismic hazards to acceptable levels of risk.

Earthquakes cannot yet be predicted with accuracy as to time, place, and severity—but progress is being made in this direction (see article page 11). The San Francisco Bay Area has been chosen as a major study for experimenting with earthquake prediction techniques for several reasons, including its potential for having many earthquakes in the near future and thereby allowing the testing of theories.

A glance at the comparatively brief historic record of this region of California shows that destructive earthquakes have been frequent. Five major earthquakes have struck the area in the two centuries which comprise its historic record. The great 1906 San Francisco earthquake had surface faulting [fractures in the earth's crust] which extended for over 400 kilometres apart as much as 7 metres.

However, the other four earlier earthquakes were also very strong.

These five major earthquakes have occurred on two well-known geologically active faults. The greater of these two faults (the San Andreas) goes through the San Francisco area and runs very close to Los Angeles; it has often been termed California's "Master Fault".

Geologic studies show that many major earthquakes have occurred on this fault over the past millions of years, and there is no reason to believe that earthquakes on it will suddenly cease now. Indeed, precise surveys conducted for over a century across the San Andreas fault show that the islands offshore from San Francisco are moving northwesterly at the rate of 5 centimetres per year with respect to the continent. This constitutes substantive evidence that strains are increasing in the earth's crust and are leading to an earthquake.

A second line of evidence is the fact that the San Andreas fault is slowly "creeping". By creeping is meant that the land masses on one side of the fault are moving with ▶

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**KARL V. STEINBRUGGE** *is perhaps America's leading expert on designing earthquake-resistant buildings. He is chairman of the U.S. National Committee of the International Association of Earthquake Engineering and chairman of the Seismic Safety Commission of the State of California. Since 1950 he has been professor of structural design at the Department of Architecture, University of California, Berkeley.*

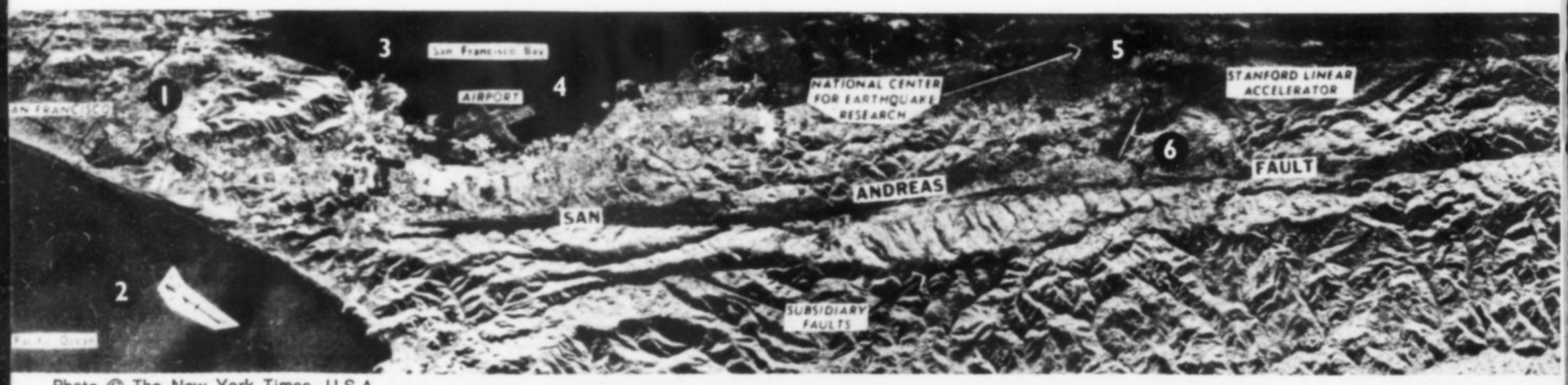



Photo © The New York Times, U.S.A.

**CALIFORNIA SPLIT.** Right, the San Andreas Fault, a major fracture of the earth's crust, comprising a system of faults extending northwestwards from the Gulf of California for nearly 1,000 kilometres. The break separates a northward moving wedge of California from the rest of North America. It goes through the San Francisco area and is very close to Los Angeles. Its movement has been responsible for frequent earthquakes, including the great 1906 San Francisco quake (see photo page 22). Above, outline of the Fault is clearly visible in this high altitude view of area near San Francisco. Numbers on photo indicate, from left to right San Francisco (1) on its peninsula, between the Pacific Ocean (2) and San Francisco Bay(3) city's airport (4) U.S. National Center for Earthquake Research (5) and site of Stanford University nuclear research accelerator (6).

Photo Georg Gerster © Rapho, Paris

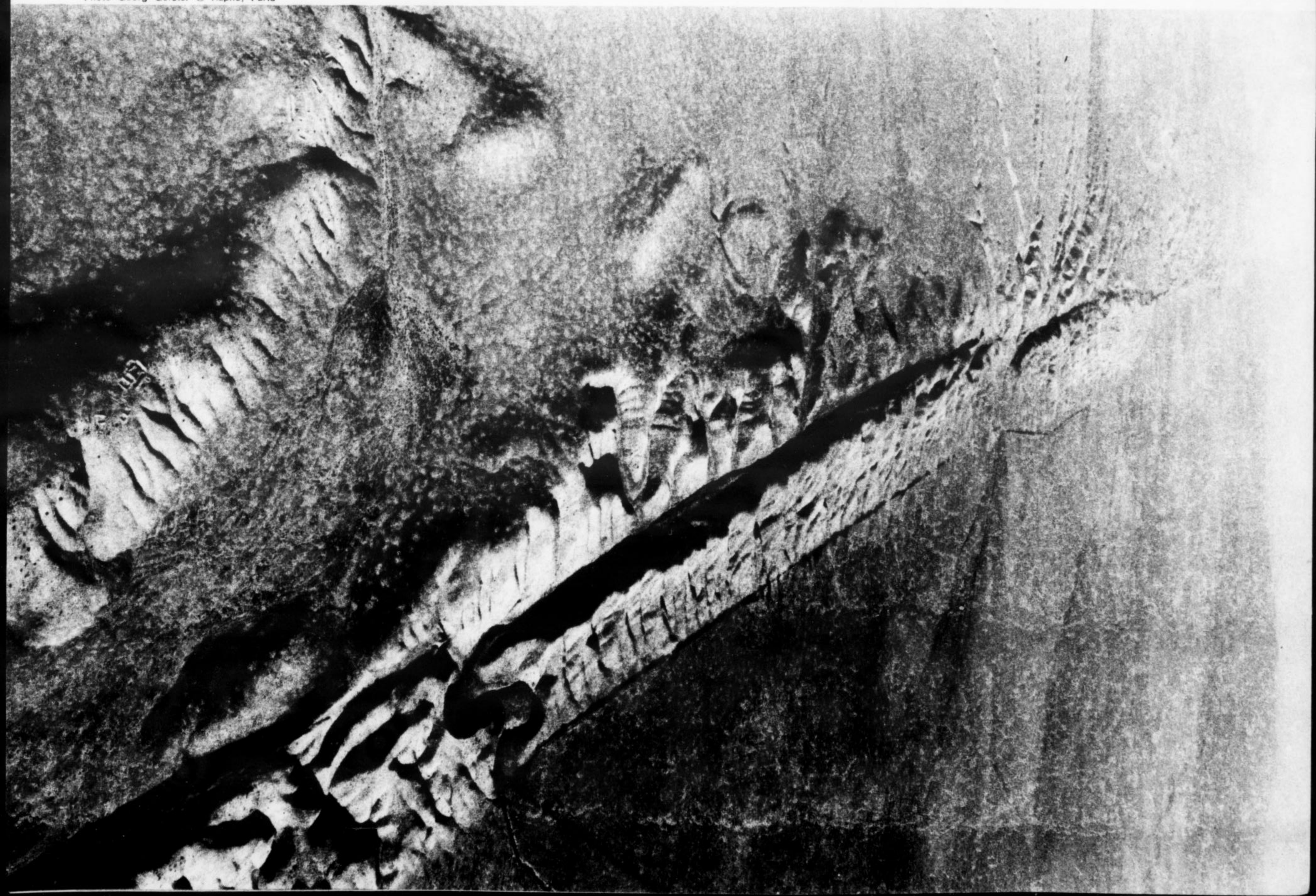


Photo © Arnold Genthe, U.S.A.

**CITY IN FLAMES. This striking view of San Francisco in flames was taken five hours after the great earthquake of 18 April 1906. Fires raged for three days because water mains had been destroyed and many buildings which survived the quake were gutted as flames swept through nearly 500 city blocks. Towns and villages along a 300 kilometre section of the earthquake-prone San Andreas fault also suffered heavily from the same quake.**

respect to the other side, but moving so slowly that only instruments can record these displacements.

This creep is not associated with recorded earthquakes, but is an evidence of strains within the earth's crust. The most prominent example is a winery south of San Francisco and on the San Andreas fault which has been in the process of being torn apart at the rate of over 1 centimetre per year for at least the past 50 years.

Certainly, the historic record plus the geologic settings are strong indications that the San Francisco area will experience a major earthquake from the notorious San Andreas fault.

On the other hand, there exists the potentially more dangerous Hayward fault which goes through major population areas within the suburbs of San Francisco. The Hayward fault has had major earthquakes on it and fault creep is taking place on it.

It is easy to conclude, therefore, that a major earthquake is a reasonable probability in the foreseeable future. It is understandable why scientists are using this area as the first major testing ground for earthquake prediction research.

Earthquakes, in themselves, are not a significant hazard. The documented cases of a fault opening up and encompassing people and then burying them can, perhaps, be counted on one's fingers. Landslides can, and do, take a very significant toll of lives, but in most cases these hazards are relatively self-evident before the earthquake and do not need an earthquake to trigger them. The major life hazard in the usual earthquake is from the collapse of man-made structures such as buildings and dams. This is certainly true for all of California as well as San Francisco.

The solution to seismic hazards is to design and construct buildings in such a manner that they will remain safe during and after an earthquake, with damage limited to acceptable economic and functional levels. Ideally, then, an earthquake would become an exciting experience, but not a hazardous adventure.

However, tearing down all existing construction and replacing it with earthquake resistant construction has overwhelming limitations. Financial and material resources simply do not exist, technologies are inadequate for some cases, and only over time can these hazardous buildings be replaced.

As a result, disaster response officials in government and in the private sector must evaluate what can be reasonably expected to occur since the hazards will remain. The United States government has completed four such studies for areas in which earthquakes are likely to occur and where their occurrence would be disastrous.

Earthquake loss studies for disaster preparedness should consider the problems from three standpoints:

- **Effects on local medical resources:** This includes damage to hospitals, medical supplies at hospitals and elsewhere, bloodbanks, structures housing ambulances, and the like.
- **Demands on local medical resources:** Planners must know what to expect as a reasonable upper limit to the number of deaths and injured, weigh these figures against the losses to medical resources, and plan for the needs that must be supplied from distant sources.
- **Effects on immediate and vital public needs:** Estimates must be made of probable damage and its location in relation to water supplies and systems, electric power, transportation, and the other items which constitute a community's "lifelines". Provision must be made to care for those made homeless from damage to dwellings, from fire following earthquake, from evacuation due to damage to or failure of dams, etc.

Time of day may be important in evaluating hazard. In California, for example, most persons will be in their quite safe wood frame dwellings at 2:30 a.m., but many of these persons

will be in significantly more hazardous structures during the working day. The season of the year is also important, since landsliding is much more likely during the wet season than during the dry season, while conflagration is much more likely in the reverse order.

The San Andreas fault is associated with the largest potential life loss. However, the nearby Hayward fault has the largest potential to disrupt disaster recovery, since many of San Francisco Bay Area's "lifelines" must cross this fault and thereby be exposed to rupture.

For example, major water aqueducts cross the Hayward fault in deep tunnels which cannot be readily repaired, and the water distribution system criss-crosses the fault. Highway and freeway bridges are located in the fault zone. Oil lines, natural gas lines, underground telephone cables, etc. frequently cross the fault.

A total of 10,000 deaths in the San Francisco area has been established as an upper limit for disaster planning purposes. This possible loss of life is horrendous, but it represents less than 1/4 of one per cent of the affected population. Fortunately, steps have been and are being taken to reduce this potential loss of life.

The 1971 San Fernando, California earthquake showed the need for Federal Government studies. Currently, active and detailed disaster response planning to these Federal studies is proceeding at all governmental levels and in the private sector. This planning will substantially reduce the time needed to restore the cities to normal, will minimize suffering, and will reduce most of the adverse effects of a great earthquake.

Response to seismic hazards and to disaster may be post-disaster oriented as mentioned above but it may also be pre-disaster oriented. While *post*-disaster response is absolutely vital, it is pre-disaster response which has the greatest promise.

At local government level, the city of San Francisco is emulating the long established Los Angeles policy of removing or bracing all hazardous non-reinforced brick parapets and appendages. Worldwide earthquake experience clearly shows that these hazards are serious even in moderate shocks.

At California state level, numerous legislative matters were acted upon and became law after the 1971 San Fernando earthquake. The details of these laws need not be reviewed here, but the following are, in the author's view, the most significant changes in public policy at California state level:

● The concept that certain facilities vital to the public *must remain functional* in addition to being safe. Recently enacted law is concerned with new hospitals, and other legislation is being considered for other types of installations. Certainly, damage *control* is a new dimension insofar as California earthquake building regulations are concerned.

● The implication in law that perfect seismic safety does not exist. The mandatory preparation of inundation maps of areas below dams clearly implies that risk exists, but also implies that public policy deems the areas to be within acceptable risk levels.

● Construction in earthquake geologically-hazardous areas is acceptable, provided sufficient engineering design and construction precautions are taken to reduce the hazards to acceptable risk levels. Thus, one may build within fault zones under specified circumstances which largely eliminate the hazards to life.

Seismic safety public policy is greatly influenced by events over which people have no control. The 1971 San Fernando earthquake stimulated existing programmes and led to new and improved policies. But from past experience, only too often the rate of hazard reduction decreases with time after the disaster.

On the other hand, the State of California created a Seismic Safety Commission which is to study public policy and to report directly to the Legislature and to the Governor. This Commission, therefore, has the potential to insure continued progress. It has been in existence for less than a year and understandably there exist no major accomplishments to measure its success. But it could be followed with careful attention as a possible model to be used elsewhere.

The remaining earthquake hazards in the San Francisco Bay Area will, in time, be reduced to acceptable risk levels, but not until the numerous older non-earthquake resistant buildings are removed.

■ ***Karl V. Steinbrugge***

Photo © The New York Times, U.S.A.

# DAMS THAT TRIGGER OFF EARTHQUAKES

**Lakes used as reservoirs seen in this photo of a section of the U.S. Pacific coastline, are formed by subsidences along the San Andreas Fault in California. Here seismic activity has helped man to solve the problem of water storage. Elsewhere many cases are known where dam construction and other engineering works have actually triggered off earthquakes. Such "induced seismicity", also caused by mining and the injection of water and liquid wastes deep underground, was studied at the first international symposium to be held on this problem, in Banff (Canada) in September 1975. More recently (at Unesco's February 1976 conference on the assessment and mitigation of earthquake risk) a Canadian geophysicist, D.I. Gough, reported that 20 cases are known of increases in seismic activity related to the filling of large reservoirs. These range from micro-earthquakes, detectable only with sensitive seismographs, to a major quake which would have caused heavy casualties if it had occurred in a densely populated area. "Known cases" he stated, "suggest that significant seismic activity may occur near a reservoir if the dam height is more than 100 metres and the water volume more than 1 billion cubic metres... As there are now more than 275 reservoirs with dam heights of over 100 M, the probability that a given projected reservoir will cause earthquakes is at least 1 in 14... As some 135 large reservoirs are now under construction or proposed, 10 to 15 new cases of reservoir-induced seismicity may be expected in the next few years."**

# EARTHQUAKES IN HISTORY

*by Nicholas N. Ambraseys*

EARTHQUAKES are the result of very slow geological processes and we need a very long period of observation before we can deduce the laws that govern them.

In spite of the large amount of data for earthquakes in this century, the period of observation is too short. To increase this period one has to resort to the study of earthquakes that took place before this century and to choose regions which have a long and well-recorded history.

One area of the globe which has a very long and well-documented history is China. Scientists in that country, studying reliable historical records over the past three millennia, have recently made significant progress in evaluating earthquake risk and in predicting regions in China where earthquakes are likely to be destructive (see article page 11).

In the western hemisphere, another region which has a long and well-documented history is the area between Italy and Afghanistan. This is currently under study at Imperial College, London, with the object of extracting from old documents such information about early events that could throw some light on the mechanisms that produce earthquakes, on the manner in which such events migrate and, in general, on the evaluation of the earthquake risk in this part of the world.

The basic data for this study is retrieved from published and unpublished documents, local histories and inscriptions written in Greek, Latin, Syriac, Persian, Arabic, Slavonic, Georgian and Turkish, as well as from the field study of early earthquake sites. This is a long-term interdisciplinary project, originally supported by Unesco and subsequently by the Natural Environment Research Council, London.

In these studies archaeological evidence is very important, particularly in regions for which written evidence is either inconclusive or scarce. Numismatics also play a significant role in assessing the destructiveness of early

**NICHOLAS N. AMBRASEYS,** *professor at the University of London, is head of the Engineering Seismology Section of the Imperial College of Science in London. He has taken part in and led Unesco earthquake reconnaissance missions to many countries, including Turkey, Iran, Yugoslavia, Pakistan, Nicaragua and Greece, and to Africa. He has been a consultant to Unesco on the restoration of the temple of Borobudur (Indonesia) and of the Parthenon (Greece). Since* 1960 *he has been a director of the International Association for Earthquake Engineering.*

Photo © The New York Public Library, U.S.A.

**Eighteenth-century engraving (opposite page) shows Lisbon ravaged by the earthquake of 1 November 1755 at 10 A.M. Twenty minutes after the tremendous shock destroyed most of the Portuguese capital and caused fires to break out, seismic sea waves engulfed the ruined city, then one of the most prosperous in the West. More than 60,000 persons died in the cataclysm. Below, late 16th-century mural in the monastery of St. Dionysius, Mount Athos, overlooking the Aegean Sea in northern Greece. The artist has sought to evoke the nightmare atmosphere of a violent earthquake by depicting, in addition to collapsing buildings, haloes around the sun and moon and falling stars.**

Photo © M. Hatzidakis, Byzantine Museum, Athens

earthquakes. The issue of new coinage and the establishment of new mints were often measures taken by the authorities to relieve regions after disastrous earthquakes.

Inscriptions recording public assistance and private generosity for the reconstruction of destroyed towns are equally valuable. Abrupt changes in building materials and methods of construction as well as the relocation of settlements are all useful in assessing the relative importance of early earthquakes.

Other factors have also to be taken into consideration. Among these are population density; uniformity and concordance of source material; natural exaggeration in the description of early earthquakes; and the varying attitudes of historians and poets throughout the ages to phenomena such as earthquakes, which reflect the importance they attach to the events they are recording.

One of the major aspects of the research is the identification of large earthquakes and the rate at which they have been occurring during the last 2,000 years. Another is the assessment of their economic and social impact on the people in the region and their effect on the environment.

Search for large earthquakes is not limited to the most populous centres. It is usually possible to determine that an earthquake felt in large towns, where it may be well documented, was felt even more severely and destructively in outlying, less cultivated areas nearer to the true epicentre, where some cloistered sage may have referred to it in the course of a voluminous history of his sect or township, or in a panegyric on his local ruler.

Large earthquakes can be identified from the size of the area over which they were felt, the duration of their aftershocks, the degree of damage wrought in the centre of the earthquake area and from the economic and social impact they have on those involved.

There is little doubt about the size of the earthquake of 21 July 365 A.D. which affected an area of about two million square kilometres in the Eastern Mediterranean, between Italy and Palestine, and Greece and North Africa. This earthquake, one of a dozen that have shaken the Eastern Mediterranean during the last two and ▶

# Seismic whiplash

**Earthquake shocks subject man-made structures to horizontal forces that most of them are not designed to withstand. Though these forces do not always totally demolish buildings, their "whiplash" effect can result in freakish forms of damage particularly as shown in photos 2 and 3.**

**1) During an earthquake at Dasht-e-Bayaz (eastern Iran) that caused 12,000 deaths in 1968, brick and adobe buildings collapsed into rubble, whereas "windshafts", rooftop kiosques providing ventilation, remained intact.**

**2) Spire of the Mustapha Pasha mosque after the earthquake of July 1963 in Skopje (Yugoslavia). Its tip has been knocked so far sideways that the minaret seems to defy the laws of equilibrium. The more flexible upper part of the spire reacted to the violent accelerations with a "whiplash" effect, the base of the minaret acting as the whip's handle.**

**3) Another example of the same effect is seen in the sections of this Doric column, dislocated by an earthquake long ago. The column supports the capital of an ancient Greek temple in Athens, dedicated to Hephaestus, god of fire and blacksmiths.**

**4) Railway lines are buckled and twisted as if made of plasticine in this photo taken after the 1964 earthquake at Niigata (Japan). Four trains in the area were able to stop in time. Their 500 passengers were obliged to spend the night in the carriages but escaped from their terrifying experience unharmed.**

1

2

Photo © M. Despeyroux, France

Photo © N.N. Ambraseys, U.K.

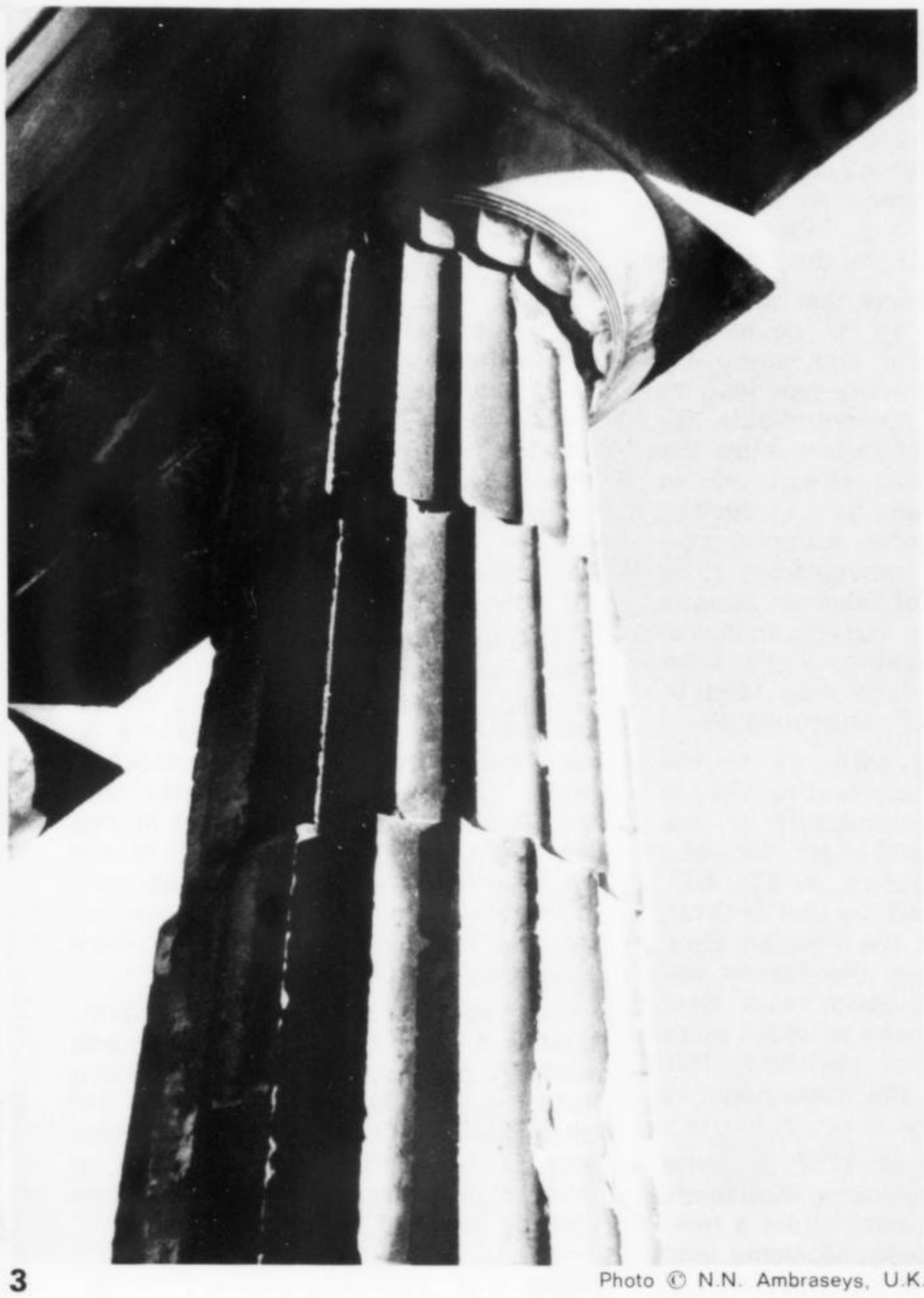
a half millennia, was associated with a catastrophic sea-wave which in Alexandria alone drowned 5,000 people.

Evidence of the social impact this earthquake had is found in the church calendar. For two centuries the event was commemorated in Egypt and Greece by a yearly festival meant to appease the sea and arrest the waves, which in 365 A.D. carried boats over the walls of towns and deposited them on roof-tops, drowning thousands of people.

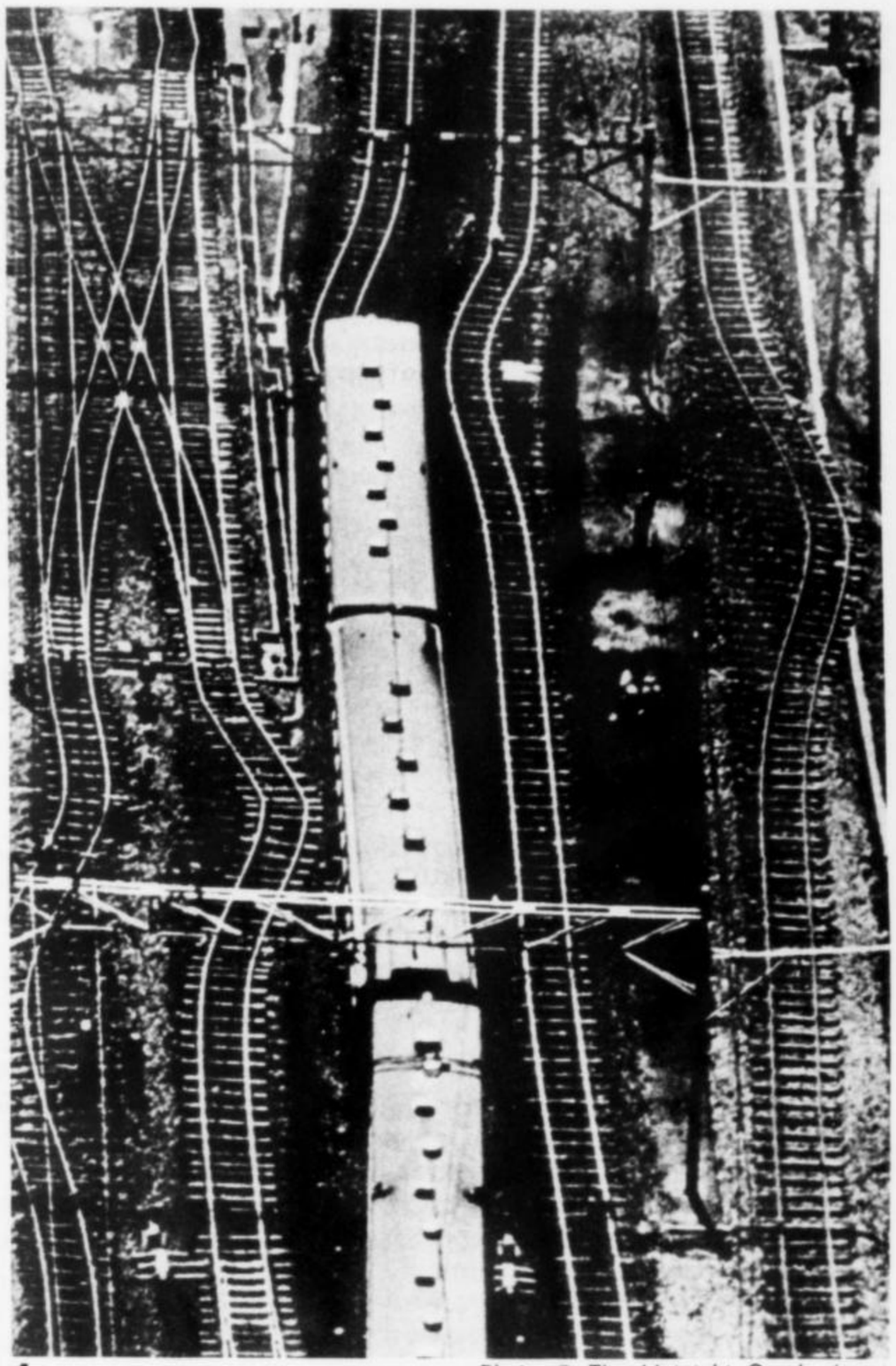
Recent archaeological evidence has shown the effects of the 365 A.D. disaster which marked the end of a number of declining towns in Libya and Sicily. Hoards of coins found on the floor of public buildings trapped by the tumbled down masses of masonry pre-date the disaster and testify to the abandonment of these sites.

Evidence of catastrophic earthquakes abounds in areas which today appear to be free from earthquakes. North-Central Iran is a typical example. During the last two millennia, sites such as Shahr-Reyy, today a suburb of Tehran, Qumis near modern Semnan, Nishapur and Juvain not far from Mashhad, and other places in Khorassan, were totally destroyed and abandoned.

Indeed, Shahr-Reyy was well known



3 Photo © N.N. Ambraseys, U.K.



4 Photo © The Mainichi Graph, Japan

for its earthquakes even during the time of Alexander the Great and the Greek name of the locality "Rhagae" meant a place "rent in an earthquake". Elsewhere, destructive earthquakes in Baluchistan and Oman, in Lebanon and Western Syria as well as near Kabul and Rawalpindi are known to have caused widespread damage.

In many instances, particularly in the western part of the area being studied, official documents of the late Roman and Byzantine periods give lists of towns that after destructive earthquakes received financial assistance from the government, as well as remission of all contributions to the exchequer for a number of years to help their reconstruction. These lists make it possible today to assess the extent of the area affected by early earthquakes.

The earliest written evidence requesting such action was actually found in tablets from Northern Iraq, dating back to the later part of the second millenium B.C. This particular request came from an ill-defined region north of Mosul, which today is considered to be almost free from large earthquakes. Similar second millennium B.C. notices have been found referring to the inability of the local rulers to pay tribute after destructive earthquakes on the Mediterranean coasts and in Syria.

During our research we have found that deterioration of the local coinage, taken together with other evidence is a good indication of the damaging effects of ancient earthquakes. This was the case, for instance, in the 25 A.D. earthquake which destroyed Taxila, in Northern Pakistan, very near modern Islamabad. The earthquake destroyed the mint and apparently killed its engravers. Similar cases have been found for Rhodes, Cyprus and Western Anatolia.

After the Taxila earthquake, houses were rebuilt stronger, with special precautions to make their foundations secure. In some cases these were carried down as much as five metres, a drastic change in building techniques noticed also elsewhere, notably in Western and Southern Anatolia and Syria, where after destructive earthquakes builders reduced the height of new houses from three to one or two storeys and the lower storey was left half buried beneath the fallen debris, and thus constituted a sort of basement.

After destructive earthquakes, towns were often rebuilt on an extensive plan with marked changes in building techniques such as unusual types of foundations, consisting of a grid of wooden beams on which the structures are built, the introduction of timber-bracing of houses and the abandonment of ordinary unreinforced brickwork. It is often assumed that these changes are due to techniques brought into the region by new settlers, or by invaders. This is not always the case.

The acknowledged advantages of timber-braced constructions in regions subject to earthquakes have conditioned building methods, for instance in Anatolia, Crete, Northern Pakistan and elsewhere, up to quite recent times, and historical as well as archaeological evidence shows that even in antiquity such a device was intended to give to a building that resilience which would increase its resistance to earthquakes, although it would decrease its fire resistance.

What puzzles archaeologists is the use of timber-bracing as a building technique in areas situated outside the regions where earthquakes are most prevalent today. This, however can be explained.

Studies of areas that have been damaged or devastated repeatedly by earthquakes during the first 17 centuries A.D. reveal quite clearly that historical earthquakes follow not only a ▶

well defined pattern but also that this pattern in places fits surprisingly well that of earthquakes that occurred during this century.

However, studies also show the occurrence of quakes in regions which today are thought to be free from large earthquakes, such as the Dead Sea, southeast Turkey and northern Syria and Iraq, the central Balkans and eastern Iran. Study shows that zones which were notorious for their destructive earthquakes, such as those in northern Syria and Iraq or east-central Iran, are quiescent today, while zones which are active today, such as Anatolia and the Zagros, were free from large earthquakes two generations ago.

Individual zones may undergo long periods of activity followed by equally long periods of inactivity, lasting many generations, during which precautionary measures against earthquakes in building houses are gradually abandoned only to be taken up again a few hundred years later. As was said earlier, the human time-scale is minutely short when compared with the time-scale involved in the geological processes leading to quakes.

EARLY and modern history shows that the lasting effects of single major earthquakes during the past twenty-five centuries would not seem to have been very significant for a developed and stable community. Soon after a large earthquake, vested interests invariably led people and their leaders to act once again with disregard for the prospect of future such calamities.

Yet modern writers have attempted to use earthquakes to account for gaps in the sequence of civilizations and for large movements of peoples, hypotheses for which there is little historical justification. Earthquakes have had little, if any, serious influence on major or global historical developments. They did often account for the premature decline of a local economy or for a crisis in local human affairs. But they have never caused the ruin of a culturally advanced state, far less the end of a civilization.

In contrast with wars, epidemics and other long-lasting calamities, earthquakes, no matter how large, seem to have had little long-term impact on Man. Personal, political, religious and in particular economic interests seem to overshadow the lessons to be learnt from earthquakes.

Take for example, Antiochia, modern Antakya in Turkey. Since its foundation the city, built partly on very soft ground, had suffered from earthquakes. In 115 A.D. the city was almost totally destroyed, but because of its strategic position was rebuilt on the same site. In 458 A.D., Antiochia was almost totally destroyed by another earthquake and rebuilt on the same spot although it was pointed out to those concerned that reconstruction on the same site was likely to be unwise.

The part of the city on the worst ground, on the river, being settled by merchants, was of course rebuilt, only to be totally destroyed a generation later with a loss of 200,000 lives. Antiochia was again rebuilt on the same site, this time becoming an important religious centre, and was finally destroyed in 540 A.D. by the Persians.

The economic effects that an earthquake may have on a developing country or on a poor community are more important and they can lead to serious and often uncontrollable disasters, far more important than the immediate destructive effects of an earthquake. The damage and sudden crippling of an unstable economy may lead to population movements, to a latent emigration of skilled people, increase in taxation and to undesirable, though unavoidable, loans from foreign countries which may lead to economic and social consequences.

For instance, as early as in the 5th century B.C. an earthquake in Sparta gave the opportunity to the subject helots to shake off the yoke of their Spartan masters. In 978 A.D. an earthquake marked the end of Siraf, a declining port on the Persian Gulf. In 1139 A.D., Gandja, the former Elizavetpol, now Kirovabad, was destroyed by an earthquake in which more than 100,000 people perished; this gave a chance to the Georgians to sack the ruined city.

The earthquakes of 1157 in Syria caused great damage, killing thousands of people. They brought about a temporary peace between Moslems and Crusaders who were too busy repairing shattered forts to think of serious aggressive expeditions for some time to come; these earthquakes caused little change to the final outcome of the crusades.

An earthquake in 1320 destroyed completely Ani, the capital of the Armenian province of Ararat, causing its inhabitants to disperse into various parts of the world, as far as Poland and Iran. The real cause for the desertion of the ruined city, however, was the decadence of the Mongol dynasty of Armenia.

In 1755, the Lisbon earthquake, on the other hand, provided an opportunity for the rebuilding of the city on a grand scale and also for reducing the trading privileges of foreigners, thus stimulating an already active economy.

At the present level of technology, earthquakes cannot be prevented. Nor for some years to come will it be possible to predict them in the detail required to safeguard the economy of a developing country.

Earthquake prediction was a constant preoccupation for the early soothsayer, astrologer or prophet, and there are many instances recorded in history of destructive earthquakes having been forecasted. Earthquake prediction is also increasingly preoccupying the modern seismologist. Even when accurate, such predictions are not particularly effective, since people seem strangely reluctant to believe that an earthquake will occur whether it is a credited astrologer or a seismologist who tells them so.

History is full of such examples, demonstrating that Man reacts to an inevitable hazard in a special way, distinct from a preventable hazard. The earthquake of 1042 A.D. in Tabriz, in Iran, was predicted by the chief astrologer, who tried in vain to persuade the people to leave. Earthquakes had happened in Tabriz sufficiently frequently to be likely to occur again, yet the main reaction to the prediction was one of apathy. The earthquake happened and more than 40,000 people perished. Subsequent predictions, allegedly accurate, were invariably ignored.

The earthquake of 1549 in eastern Iran was also predicted by the Cadi [judge] of that place who tried unsuccessfully to convince his people to stay out in the open that particular night. They refused to listen and the Cadi stayed out alone, but finding the night very cold returned to his house where he soon perished with 3,000 people in the district. Apparently, the Cadi himself was not too sure about his prediction.

Our research shows that with earthquakes it is not only the prediction and warning problems that are important but also the social and economic implications of forecasting such disasters. False alarms and inaccurate timing might create more problems than already exist.

TODAY, earthquake prediction would be welcomed by scientists and engineers, but for the general public it is not certain whether this would solve more problems than the social, economic and even political ones that it must create.

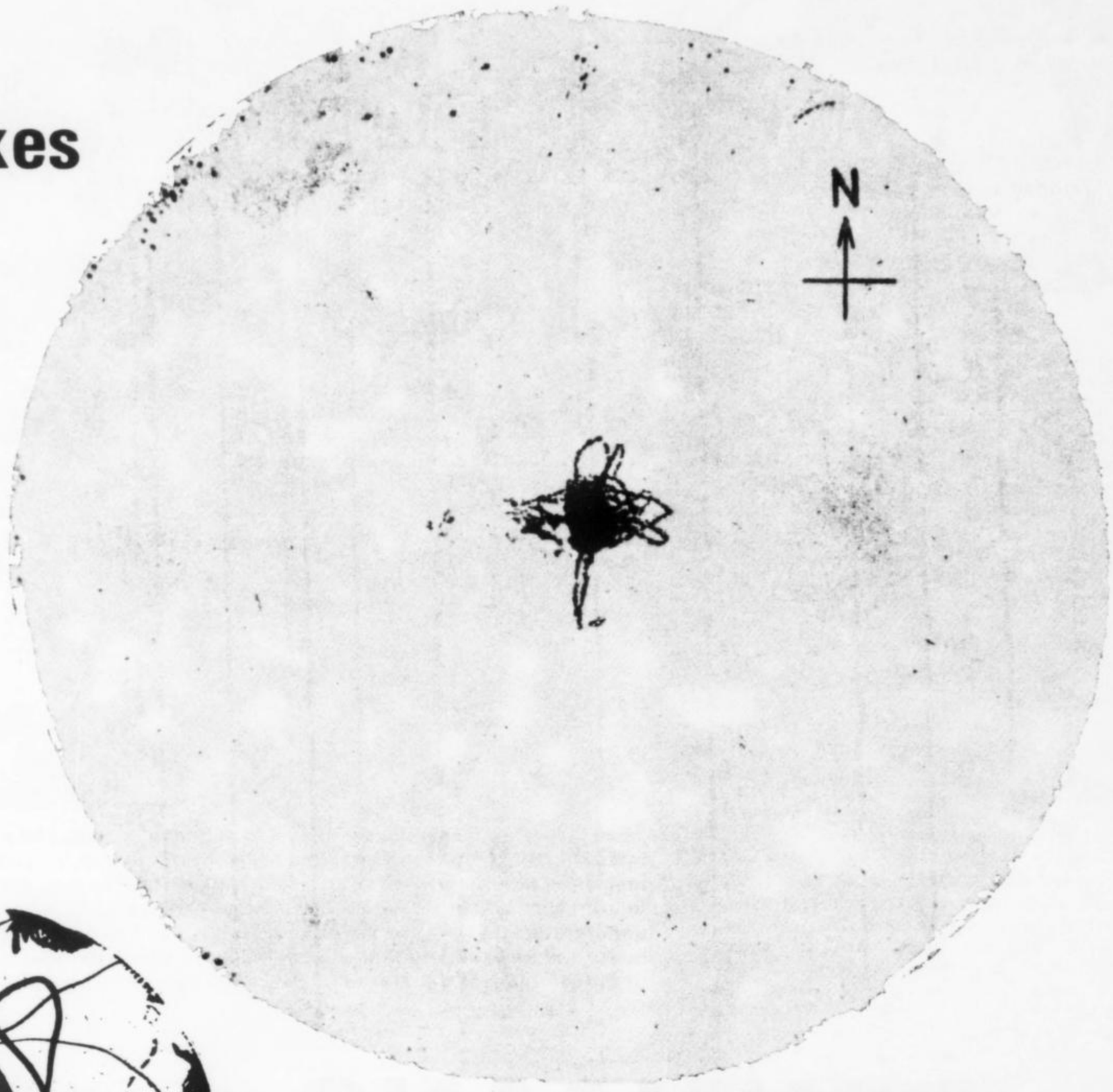
There is no denying that there is at present a lack of knowledge of facts regarding earthquake risk in many parts of the world and that it is through the study of the historical record that such facts may become known. In spite of the recent rapprochement between archaeologists, historians and earth scientists, a proper link for the study of subjects of mutual interest such as early earthquakes, volcanic eruptions, weather changes, droughts and floods, has not been formed.

Work on these subjects is being pursued singly and with little co-operation or guidance from other fields of knowledge, a process which is not only painfully slow, but one which is fraught with danger of misuse of other disciplines.

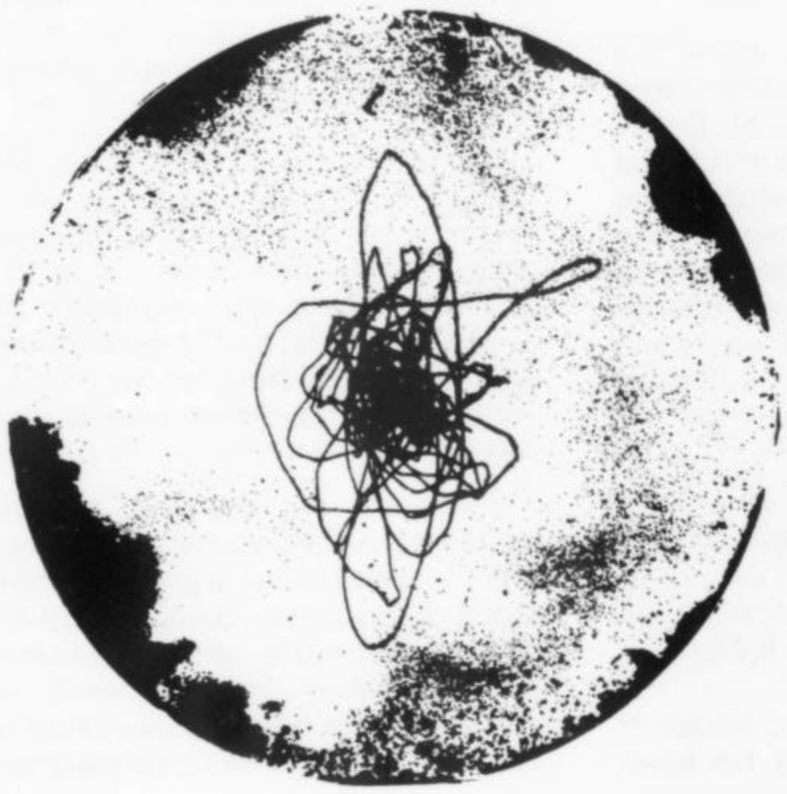
The need for a co-ordinated research programme on historical earthquakes and other natural hazards is obvious. Such research, the scope of which is international and global, will give further dimension to our knowledge of what Nature has in store for us.

■ ***Nicholas N. Ambraseys***

# How earthquakes sign their names



These curious squiggles are earthquake "signatures", recorded on a seismoscope. The one above was made by a quake at Bandar-Abbas (Iran) in March 1975. The others were registered in December 1972 during an earthquake which struck Managua, capital of Nicaragua, destroying three-quarters of the city and killing, 10,000 of its 400,000 inhabitants. Results obtained from seismoscopes located 5 km west of Managua in an oil refinery at the very epicentre of the earthquake showed shock waves accelerating towards the east, thus causing the Managua disaster.



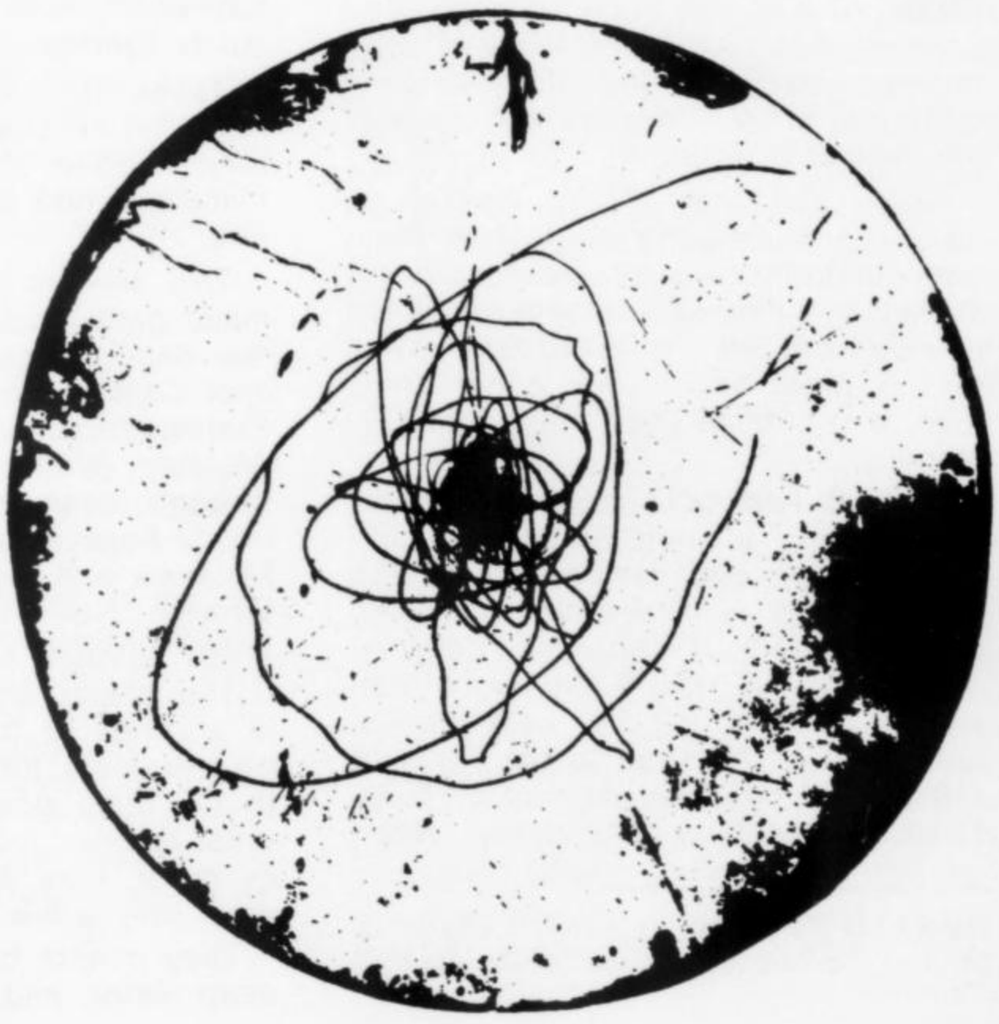


Photo © Intergovernmental Oceanographic Commission's International Tsunami Information Center, Hawaii, U.S.A.

Above, towering seismic sea wave, or tsunami, strikes the shore at Hilo (Hawaii). An instant after the photograph was taken by an unknown seaman on 1 April 1946, the man seen at left (arrowed) was swept to his death—one victim among 300 killed or injured that day in Hawaii. The tsunami had been triggered off five hours earlier by an underwater quake in the Aleutian trench 4,000 km. to the north. Right, capsized fishing boats and smashed buildings on a Japanese beach demonstrate the shattering force of tsunami waves generated in May 1960 by an earthquake in Chile 16,000 km. away.

# TSUNAMIS ocean waves of death and destruction

EVERY island and coastal settlement in the Pacific Ocean area is vulnerable to the onslaught of seismic sea-waves, the destructive oceanic offspring of earthquakes (or seisms) and volcanic eruption.

Some call them "tidal waves", a name as misleading as it has been persistent; these great waves are not caused by tides. The Japanese, whose islands have felt the destructive power of the great waves for generations, give us the name used internationally: tsunami.

In 1868 and 1877 tsunamis devastated towns in northern Chile, and caused death and damage across the Pacific. A series of seismic sea-waves generated by the eruption and collapse of Krakatoa in 1883 killed more than 36,000 persons in the East Indies. Japan lost 27,000 lives to the wave of 1896, and 1,000 more to that of 1933. There have been hundreds more whose effects were less spectacular but which took many lives and did much damage.

Tsunamis occur most often in the Pacific. Around this immense ocean runs a zone of extreme seismic activity crowned by a volcanic "Ring of Fire."

This seismic belt extends along the major geologic faults, or fractures, and the deep oceanic trenches of South and Central America and the United States, turning westward along the Aleutian Island arc, then southward through Japan and the Philippine Republic; here it branches westward to Malaysia and Indonesia, and eastward through New Guinea, the southern island groups, and New Zealand.

The phenomenon we call "tsunami" is a series of travelling ocean waves of extremely long length and period. In the deep ocean, their length from crest to crest may be a hundred miles or more, their height from trough to crest only a few feet.

They cannot be felt aboard ships in deep water, and they cannot be seen from the air. But the kinetic energy—the energy of movement—represented by a tsunami is impressive: a tsunami "feels the bottom" even in the deepest ocean, and it appears that the progress of this imperceptible series of waves represents the movement of the entire vertical section of ocean through which the tsunami passes. In the deep ocean they may even reach speeds of over 900 km. per hour.

As the tsunami enters the shoaling water of coastlines in its path, the velocity of its waves diminishes and wave height increases. It is in these shallow waters that tsunamis become a threat to life and property, for they can crest to heights of more than 30 metres and strike with devastating force.

Tsunamis are believed to originate as displaced columns of ocean water, but the displacing agent has not been positively identified. Seismic or volcanic alterations of the ocean floor, provided they impart some vertical movement to the water column, may cause tsunamis. Submarine ava-

**RONALD FENTON** *is editor in charge of the English-language edition of the Unesco Courier.*

Photo © The Mainichi Graph, Japan

# International warning system

*by Ronald Fenton*

lanches on the slopes of the Pacific trenches may also produce tsunamis.

Although it has been established that a relationship exists between seismic or volcanic disturbances and tsunamis, the nature of this relationship is not well-defined. Tsunami magnitude appears to be a function of earthquake magnitude and depth, water depth where the tsunami is generated and the extent to which the earth's crust is deformed by the earthquake. But the combined effect of these factors is still imperfectly understood.

The speed of tsunamis varies with water depth, and it is this relationship which permits prediction of tsunami arrival times at all points in the Pacific Ocean area.

A tsunami warning system and an international tsunami information centre serving all areas of the Pacific have been set up at Honolulu, capital of Hawaii. Their work has done much to reduce the hazards of the tsunami—the most destructive of all waves.

Using seismographs and tide-gauges scientists are able to predict almost exactly when a tsunami will arrive at a given seacoast since tsunamis are known to travel at speeds that may average from 650 to 800 kilometres an hour, the exact speed depending on the depth of water over which they pass.

But it is still not possible to predict what effect the topography of the ocean floor will have on a tsunami. It is not completely clear, for example, why a tsunami's wave may be of negligible size at one beach, and of giant proportions a few miles away.

What is certain, however, is that all tsunamis—like hurricanes—are potentially dangerous, even though they may not strike each Pacific coastline or do damage at each coastline they strike. So a constant tsunami watch has to be kept and the peoples of the Pacific alerted when the great waves roll across the world's largest ocean. ■

**THE Tsunami Warning System in the Pacific is an international co-operative operation designed to predict the arrival of seismic sea waves (tsunamis) and to alert countries throughout the Pacific region. In 1965 Unesco's Intergovernmental Oceanographic Commission set up an International Tsunami Information Center which now works closely with the Tsunami Warning System in the Pacific, operated by the United States Weather Service from a headquarters near Honolulu (Hawaii).**

**The International Information Center provides aid in the establishment of national tsunami warning systems and technical advice on the latest warning system equipment. It also maintains a computerized storage and retrieval system on tsunami data.**

**Unesco's Oceanographic Commission also established an International Co-ordination Group for the Pacific warning system which today numbers 15 member countries (1).**

**The first tsunami warning system in the Pacific was set up in Hawaii by the U.S.A. in 1948, two years after a destructive tsunami took the islands by surprise, killing or injuring over 300 persons and causing widespread damage. Subsequently, the need for a broader based international network was shown when major tsunamis swept across the Pacific—from a submarine quake off Kamchatka in 1952 and from others near the Aleutians (1957) Chile and Peru (1960) and Alaska (1964).**

**The present Tsunami Warning System in the Pacific operates primarily through two lines of detection. The first is a network of over 30 seismograph stations which pick up the shock waves of earthquakes and then determine their magnitude and location. If the shocks are strong enough and if the focus of the quake is under the ocean or close enough to it to disturb the ocean floor a tsunami may have been generated.**

**The warning system H.Q. in Honolulu reports the fact to all participant countries and issues a preliminary alert that includes the estimated time of arrival of a possible tsunami.**

**The system then turns to its second line of detection: a network of more than 50 tide stations where gauges record the cycle of the tides continuously. Such gauges record tsunamis as abnormal phenomena.**

**When confirmation is received by the Honolulu H.Q. it alerts all countries to the approach of a potentially destructive tsunami.**

**New operational methods are now being developed for the tsunami warning system. Use of the latest technology and instruments will reduce the time needed to evaluate the tsunami hazards. The system will use a large network of ocean bottom and shore based seismic and tsunami sensors to transmit data to Honolulu and will eventually rely on space communication satellites.** ■

(1) Canada, Chile, China, Ecuador, France, Guatemala, Japan, Rep. of Korea, New Zealand, Peru, Philippines, Singapore, Thailand, U.S.A., U.S.S.R.

# Was Atlantis an island in the Mediterranean ?

CAN the disappearance of the legendary continent of Atlantis, described by Plato in his *Dialogues* and the subject of so much controversy and theorizing, be explained in terms of an ancient seismic catastrophe in the Aegean Sea? Some archaeologists believe so or at least that the seismic history of the eastern Mediterranean can throw light on the sudden collapse, around 1500 B.C. of the Minoan empire and the Cretan civilization, one of the greatest of Antiquity.

We now know that 3,500 years ago the eastern Mediterranean was the scene of one of history's most gigantic natural disasters: the explosion (around 1480 B.C.) of the volcanic island of Santorin, 100 km north of Crete. The explosion sent millions of tons of volcanic ash hurtling into the atmosphere, giving rise to intensive atmospheric shocks and generating devastating tsunamis that destroyed many ports and towns of the Minoan empire.

Examining this cataclysm and the theories that have been put forward about it, notably by Prof. Spyridon Marinatos, Director of the Greek Department of Antiquities, George Pararas-Carayannis, Director of the International Tsunami Information Center in Honolulu, writes : "Recent archaeological work on the island of Santorin unearthed, partly submerged below the sea, a completely intact 3,500-year-old Minoan city. Excavations by the University of Athens uncovered one-, two-, and three-story houses and numerous Minoan artifacts and utensils. The absence of human skeletons from the city indicates that the inhabitants had advance warning of the oncoming eruption of the volcano and had time to evacuate the island". The volcanic eruption and the tsunamis alone did not destroy entirely the Minoan civilization. But for two centuries the Minoan civilization on Crete was weakened by numerous earthquakes that destroyed its cities and caused it to decline rapidly.

As for the legend of Atlantis, he concludes, "Whether Santorin and the other Minoan colonies on the Aegean islands actually constituted the lost continent of Atlantis may never be known with absolute certainty." ■

Photo David Seymour © Magnum, Paris

**Santorin in the Aegean Sea (see map below) was once a volcanic island almost 1,500 metres high. Around 1480 B.C. it erupted. The crater blew sky-high, and then the whole mountain collapsed, forming a huge cavity in the sea. Into this cavity rushed some 62 billion m³ of sea water creating waves that reached hundreds of metres in height. Then just as quickly excess water rushed out setting off giant waves (tsunamis) in all directions across the Mediterranean at speeds of over 500 km per hour. Above, Thira, chief town of Santorin (also called Thira) dominates a circular lagoon, where the sea replaced the vanished crater. Of ancient Santorin there remains only the little group of islands seen in photo below. This, according to one theory, is the source of the legend of Atlantis.**

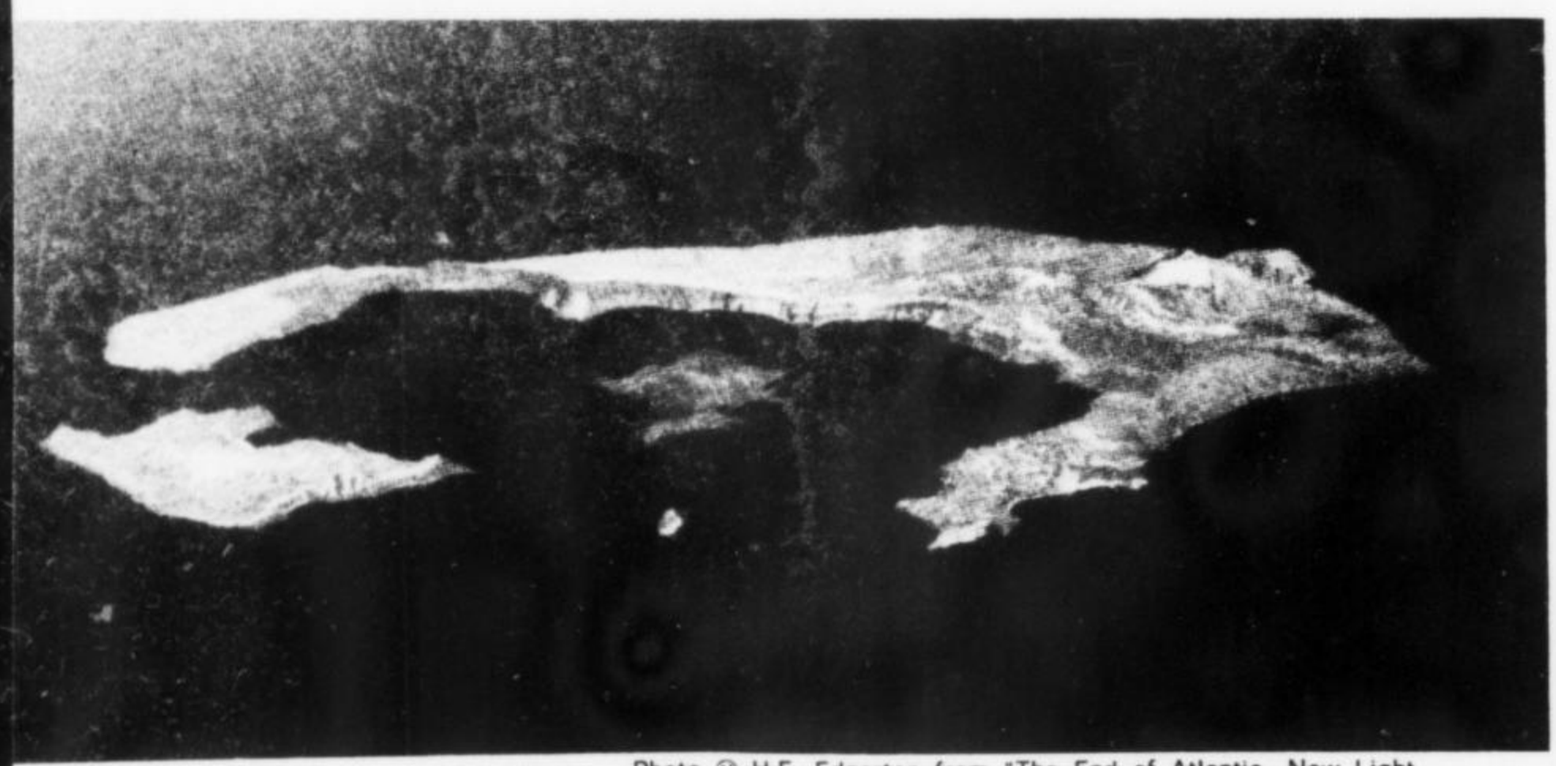
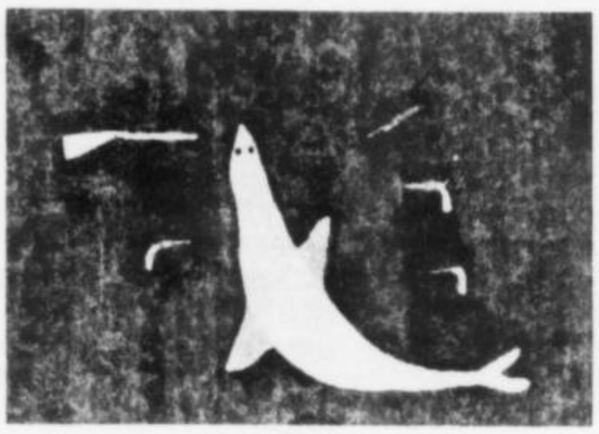


Photo © H.E. Edgerton from "The End of Atlantis - New Light on an Old Legend", by J.V. Luce © Thames and Hudson, London 1969

# Letters to the Editor



## SCHOOL CHILDREN'S PLEA : STOP THE SLAUGHTER OF BABY SEALS

Sir,

Shocked by the slaughter of seals off Labrador since 16 March 1976, we wish to express our surprise and distress that such barbaric acts are still allowed to take place in spite of widespread condemnation in the last few years and protests by leading world figures.

We appeal to you to urge international organizations to do all they can to put an end to this horrifying and unspeakably cruel massacre, which is rapidly leading to the extermination of an entire species of animals and causing a totally unjustifiable disruption in the precious balance of nature.

In this petition we add our protests to those voiced by Canada's "Green Peace" organization and the International Fund for the Protection of Animals, as well as those made by France's Society for the Protection of Animals and by thousands of people who do not know how to express their indignation effectively.

We solemnly promise **never** to buy anything which has been made from the skin of these—or any other—wantonly massacred animals. Hoping that our plea will be heard and that it will help to save those baby seals which are still alive.

**Signed:**
**Madeleine Müller (teacher) and 74 pupils of the lycée of Rambouillet, France**

## THE NUCLEAR NIGHTMARE

Sir,

Congratulations on your November 1975 issue, "30 Years After World War II". Of particular interest was the series of articles entitled "The Nuclear Nightmare" by the Stockholm International Peace Research Institute. I wholeheartedly agree with what the authors say about the nuclear deterrent and the scandal of arms spending and the arms industry (and hence about economic growth based on arms sales). Above all they emphasize the danger that the peaceful uses of nuclear technology will foster the proliferation of nuclear weapons.

But, I part company with your contributors when they imply that nuclear power must inevitably be used in research and in energy production. They maintain that atomic energy is economical and that "the electricity produced by nuclear-power reactors is cheaper" (than that generated by coal- and oil-fired power stations).

I do not agree that electricity produced by nuclear-power reactors is an economic proposition. The Americans have published sufficient statistical evidence on the operating costs of their nuclear-power reactors to prove that they are hopelessly uneconomical.

Harnessing atomic power to generate electricity consumes more energy than it produces. In most countries this fact is concealed because of military and political considerations or by a massive conspiracy of economic interests designed to benefit companies with a vast range of activities.

In calculating the cost of producing energy by nuclear power, the following factors must be taken into account: the costs in terms of energy and capital of prospecting for and extracting ores for fuel; the disposal of nuclear wastes; the costs of reprocessing fuel elements, enriching uranium and setting up control and safeguards systems: the risk of accidents. We must also take utilization factors into account (remembering that nuclear reactors are hardly ever used to their full capacity) as well as breakdowns which sometimes put reactors out of service for years.

You do not say that experts predict that the world's supply of uranium ore will run out around 1980-1985, that colossal dangers are involved in operating breeder reactors and that reactors pollute the environment with liquid and gas effluents. If some scientists and engineers disagree on these points, it simply shows that no scientifically proved definitive conclusion has been reached in this field.

Your contributors do not indicate that the safe disposal of high-level waste for centuries if not thousands of years poses insoluble problems. Nor do they point out that radiogenic heat acts on vitrified wastes, that containers dropped in the ocean are only designed to resist pressure and corrosion for ten years, and that the storage of atomic wastes in containers must be carefully supervised, with the substances refrigerated and decanted (since radiation causes the containers to corrode and fissures to develop in them). Moreover, little is known about either tectonic movements on the ocean floor or about undergound water movements. Thus there have been instances in the U.S.A. of radioactive spring water re-emerging near mines where wastes have been deposited.

**Guy Clergue**
**Météo Chaudron Réunion**
**Saint-Clotilde - Réunion**

## MISSING MILESTONES IN WOMEN'S EMANCIPATION

Sir,

It is unfortunate that the "Unesco Courier" should have omitted some important facts in its March 1975 issue devoted to International Women's Year.

The chronological list of "Milestones towards emancipation" failed to give a true and complete picture of women's achievements. Out of 60 places cited, less than a dozen are in India, Latin America and Africa as opposed to 50 in Europe and the U.S.A.

Many "milestones" were missing from the list. For example, there was no mention of women who have achieved high political office in American and Asian countries. I have in mind Mrs. Indira Gandhi, Prime Minister of India, Mrs. Golda Meir, former Prime Minister of Israel, and Mme Isabel Martinez de Perón, who as President of Argentina was the first woman to achieve the highest political office in a contemporary state.

In my view your references to women in the liberal professions gave an incomplete impression of women's attainments; it would have interested readers to have a more global picture of women's activities in the world today.

**Prof. Roberto Luis Liñares**
**Buenos Aires**
**Argentina**

## IN SEARCH OF GLOBAL HARMONY

Sir,

In the world today there is a widening gap between rich and poor, between industrially developed countries and developing, non-industrialized countries, between the literate and the illiterate. Failure to close this gap could one day cost millions of lives.

At this key moment in history an important international publication like the "Unesco Courier" should discuss subjects of global interest with a bearing on this problem: an international economic system designed to serve mankind's needs instead of generating profits for certain regions of the world; new forms of art giving deep satisfaction rather than superficial enjoyment; an international political system that recognizes the interdependence of all peoples; a new global civilization and a world fellowship of nations.

The task of creating global harmony depends ultimately on the efforts of every man and woman. And the "Unesco Courier" is in a position to communicate this idea to the peoples of the world.

**Siripelle Karunaratne JA**
**Spanga, Sweden**

## NOT TO BE SHRUGGED OFF

Sir,

I am delighted to give my name to the 50 children of the primary school at Etterbeek and their teachers, whose "open letter" on world events was published in your February 1976 issue.

I write this not only for myself but on behalf of many persons who would be capable of reading such a letter not "with a shrug of the shoulders" but with pleasure at realizing that such children and teachers exist.

I should also like to congratulate Mr. Basil Hembry on his acute analysis of the arms race, that cancer of modern society and its consequences (in the letters page of the same issue).

**Moisés**
**León, Spain**

## BOOKSHELF

### RECENT UNESCO BOOKS

■ **Unesco Statistical Yearbook 1974.** Latest edition of Unesco's reference book of vital statistics from many countries on: population, education, science and technology, libraries and museums, book production, newspapers and periodicals, paper consumption, film and cinema, T.V. and radio. 1975. 894 pp. (180 F)

■ **The Aspirations of Young Migrant Workers in Western Europe,** by Robert de Montvalon. ("Educational Studies and Documents" series, No. 21), 1976, 38 p. (6 F)

■ **Teaching and Learning.** An introduction to new methods and resources in higher education. By Norman MacKenzie, Michael Eraut and Hywel C. Jones. 1970, 2nd edition revised 1976. Co-published with the International Association of Universities, 224 pp. (30 F)

■ **Reflections on Lifelong Education and the School,** edited by R.H. Dave. (Unesco Institute for Education monographs, No. 3) 1975, 80 pp. (6 F)

■ **Social Sciences in Asia I: Bangladesh, Iran, Malaysia, Pakistan, Thailand.** ("Reports and Papers in the Social Sciences" series, No. 32) 1976, 54 pp. (8 F)

# UNESCO NEWSROOM

## Venezuela's $2 million gift to Unesco cultural fund

With a donation of $2 million, Venezuela becomes the first country to contribute to the International Fund for the Promotion of Culture set up by Unesco's General Conference last year. The Fund aims to promote cultural projects in Unesco Member States with voluntary public and private help, cultural development being regarded as an essential aspect of general development and as a factor in improving the quality of life and strengthening cultural identity.

## Rites of Spring

Springtime is carnival time. The latest issues of Unesco's international quarterly *Cultures* (Vol. III, Nos. 1 and 2) take the armchair traveller for a world-wide tour of the most spectacular festivals and carnivals: Basle, Trinidad, the Fujenti Rites of the Madonna dell'Arco in Naples, Andalusia and Catalonia in Spain, Georgian and Bulgarian festivals, folkloric and religious processions at Binche and Bruges in Belgium, among other traditional festivals and feasts.

## Guru Tegh Bahadur, defender of religious freedom

India has recently commemorated the 300th anniversary of the death of Guru Tegh Bahadur, the ninth of the ten Gurus (religious leaders) of the Sikh faith. Born at Amritsar in the Punjab in 1621, Tegh Bahadur, a musician and poet, became spiritual leader of the Sikhs in 1665, at a time of growing religious intolerance and persecution in India, and took up the cause of freedom of worship of the Hindus. Detained on the orders of the Emperor Aurangzeb, he was commanded to change his faith or be executed. He chose to give his life for the cause of freedom of worship and in November 1675 was beheaded at Chandni Chowk, Delhi. A biography, "Guru Tegh Bahadur, Prophet and Martyr", by Trilochan Singh, was published by the Gurdwara Parbandhak Committee in Delhi, in 1967.

## ANNE-MARIE MAILLARD

**On 13 March 1976 our friend and colleague Anne-Marie Maillard, photo editor of the *Unesco Courier,* died after a short illness. She was 32 years old. She had been a member of the editorial staff of the *Unesco Courier* since 1 September 1971. To her post she brought a broad cultural background and a youthful eye, alert to original and striking illustrations from all continents and all cultures. She helped to transform our magazine and bring distinction to its pages. To her outstanding professional gifts were added a rare sense of tact and human warmth. It is with deep sorrow that we pay this tribute to her memory.**

The editorial staff
of the *Unesco Courier*

## UNESCO LAUNCHES FREE BRAILLE MAGAZINE

**The first number of the "Unesco Braille Review", a magazine that aims to inform blind people on themes in Unesco's fields of competence, appeared in April 1976 in English, French and Spanish. It will be distributed free throughout the world. The magazine is produced by Frederick Potter, a long-serving Unesco staff member who lost his sight during World War II, and its articles will be selected from Unesco's publications.**

**The first issue of the "Unesco Braille Review" consists exclusively of articles from the "Unesco Courier". The articles are relatively short (even a 300-page novel fills four to five bulky volumes when transcribed into Braille); they deal with subjects of special interest to the blind, such as music and travel ("Blind people's movements are often restricted", says Potter, "but in this way they can travel with their fingers"); they have a broad general appeal to help meet the special need for Braille literature in developing countries.**

**Thus, of the eight items in "Unesco Braille Review" No. 1, "A Stone Age Orchestra" and "Music, Dance and Ecstasy" deal with music, the "Journal of a Young Burmese Girl" and articles on the Celts and the Eskimos supply armchair travel, while "An Open-Air Museum in Niger" has a technical interest, since the museum has been specially arranged to allow blind people to appreciate it. Articles on the world's mineral resources and the work of the United Nations Children's Fund complete the general appeal.**

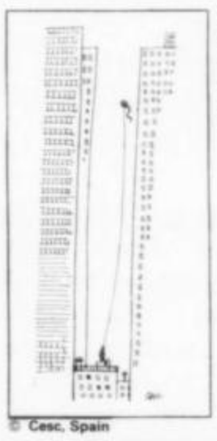
**The English language edition of the "Unesco Braille Review" will be printed and distributed in London by the Royal National Institute for the Blind. Early production of the free magazine will be limited in the print-run and the number of issues—one this year, with two more expected in 1977.**

**In an introduction welcoming blind people to "the world-wide circle of readers of Unesco publications", Unesco's Director-General, Mr. Amadou-Mahtar M'Bow writes: "From its very early days, Unesco has been concerned with the improvement of educational and welfare facilities for people without sight, through such activities as the Braille Uniformity Programme, the creation of the World Braille Council, the publication of a unique reference work, "World Braille Usage", and in more recent years, Special Education projects for the Handicapped and the provision of items of equipment for schools and training centres for the blind in developing countries".**

**In conclusion Mr. M'Bow says he regards the launching of the "Unesco Braille Review" as "one of the happiest and most noteworthy events of Unesco's thirtieth anniversary year".**

**Owing to a printing error beyond our control the cartoons on page 27 of our April issue carried no credit lines. They are indicated below with miniature reproductions of the cartoons.**

HIGH-RISE CUT DOWN TO SIZE



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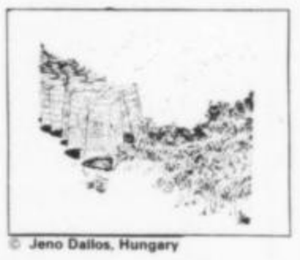

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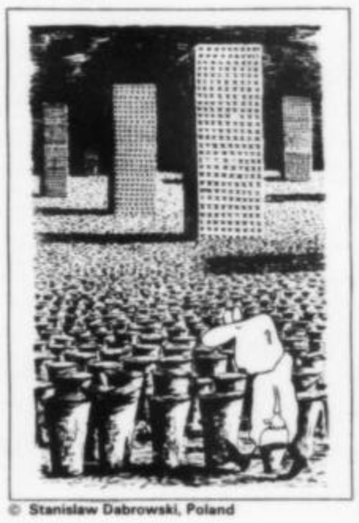

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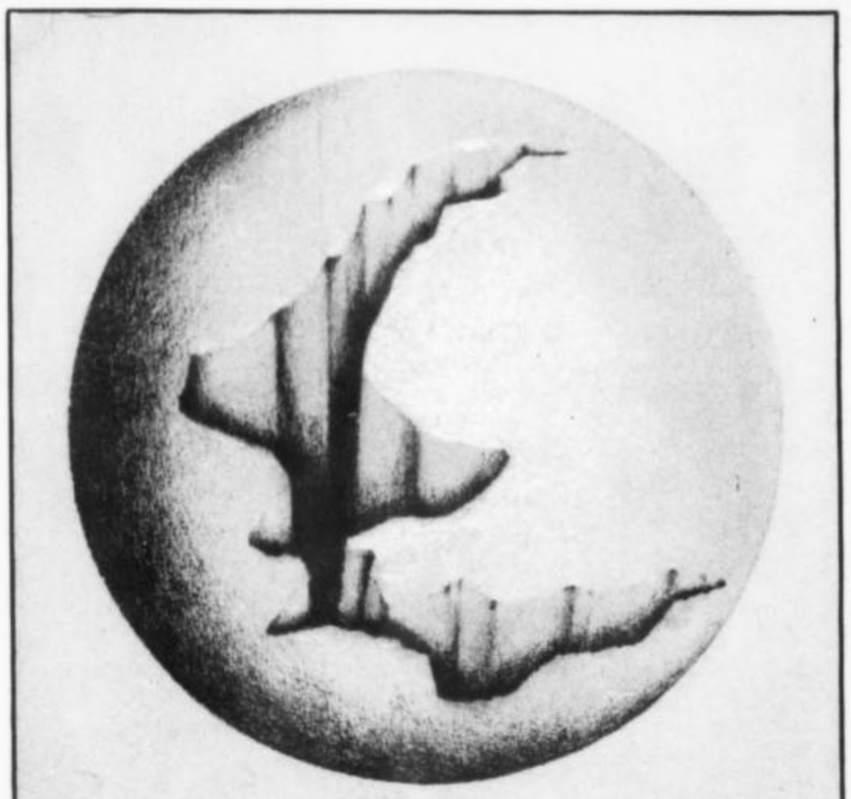

1973

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# PAGAN

## Burma's quake-shaken city of 2,000 pagodas

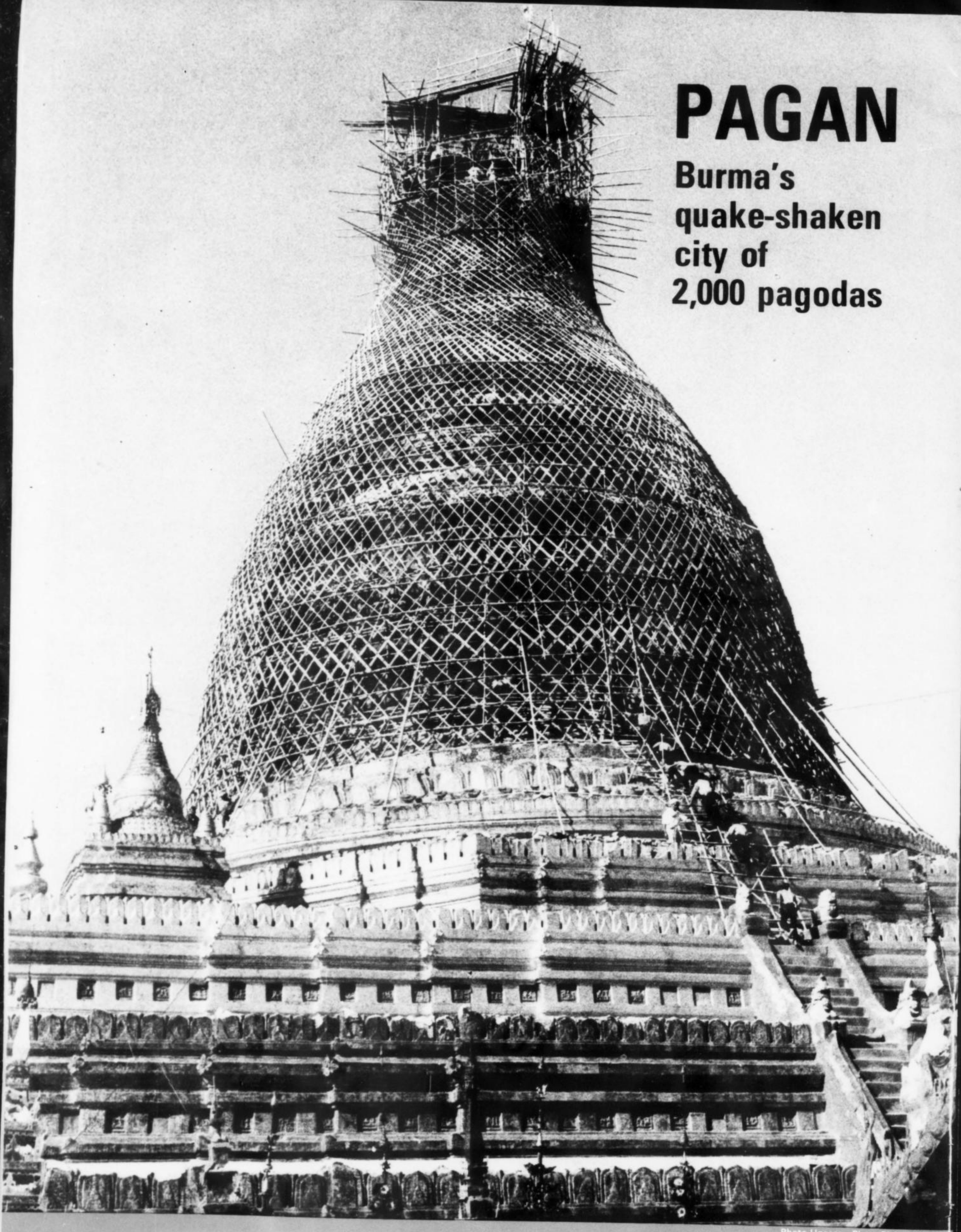

Photo Unesco - Pierre Pichard

On 8 July 1975 an earthquake damaged Pagan, Burma's ancient city of 2,000 Buddhist pagodas. Photo shows gilded stupa of Shwezigon pagoda during restoration. (See article page 14.)